



Master Thesis

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Identifying Suitable Areas for Urban Development in Rampur Municipality, Palpa District, Nepal

By

Ashim Babu Shrestha

GIS_103422

A thesis submitted in partial fulfilment of the requirements of
the degree of
Master of Science (Geographical Information Science & Systems) – MSc (GISc)

Advisor (s):

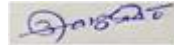
Dr. Shahnawaz

Kathmandu, February 13, 2016

Science Pledge

By my signature below, I certify that my thesis report is entirely the result of my own work. I have cited all sources of information and data I have used in my project report and indicated their origin.

Kathmandu / February 13, 2016

A small rectangular box containing a handwritten signature in blue ink.

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Signature

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Abstract

Identifying suitable areas for urban development is one of the critical issues of urban planning in hilly areas in Palpa district. The study illustrates the use of GIS suitability criteria and weighted overlay analysis technique for selection of suitable areas for urban development in Rampur municipality. The main objectives of this thesis is to identifying suitable areas for urban development of Rampur Municipality, Palpa. The sub-objectives are to develop structure of geodatabase of the study area, to analyse land use land cover of the study area 2015 and to identify the areas suitable for urban development. For this purpose panchromatic and multispectral satellite image data were used to generate for land use land cover map using digitalization and visual interpretation method in ArcGIS software. The criteria using five parameters i.e. geology, elevation, slope, aspect, and LULC and the method of Suitability Criteria and Weighted Overlay Analysis were used for identifying the suitable areas for urban development. The eight categories are Agriculture, Commercial, Forest, Industrial, Public Use, Residential, Road and Water Bodies were used for LULC map. The structure of geodatabase was prepared for LULC and urban development.

Keywords: Urban Development, LULC, Geodatabase, GIS, Suitability Criteria, Weighted Overlay Analysis

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Chapter- 1: Introduction

1.1 Background

Land is one of the important and precious natural resources of the earth surface. The demands for arable land, grazing, forestry, wild-life, tourism and urban development are greater than land resources available. In the developing countries, these demands become more pressing every year and the population dependent on the land for food, fuel and employment will double within the next 25 to 50 years (FAO, 1993). The economic and social lifestyles of most of the Nepalese are intimately related to land. Hence, urban planning for making the best use of the limited land resources is inevitable.

However, space science technology known as satellite remote sensing (RS) and the Geographic Information System (GIS) can be helpful in acquiring spatial/temporal data, and preparing digital data base. These spatial databases together with data on different land characteristics that could be collected from field survey certainly will be helpful in decision making support system for an efficient management of resources in municipality level.

On the April 16, 2012, the Government of Nepal has approved the National Land Use Policy, 2012 with an intention to manage land use according to land use zoning policy of the Government of Nepal and outlined six zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area. The policy has defined the respective zones as per the land characteristics, capability and requirement of the lands. The VDCs and municipality of Nepal lack proper base map. They are mostly dependent on 1:25,000 or 1:50,000 scale topographic maps, Land resources maps or other available analogue maps which is not sufficient or too coarse to use for municipality level planning. The available maps are also not much useful for proper decision making

process of the municipal development activities. The lacking of digital geographic information in Nepal, particularly large scale, has resulted ineffective and inefficient planning activities in urban development. Thus, the National Planning Commission of Government of Nepal has given utmost priority for the preparation of digital land use zoning data base of district, VDCs and municipalities of Nepal for sustainable development.

1.2 Research Problem and Motivation

Rampur Municipality is fastest growing city by the major factor for rapid urbanization and high migration rate in Nepal as well as in Palpa district of Nepal. Rampur represents the rapidly urbanizing municipality in the Nepal, which needs comprehensive city plan for the establishment systematic dreamland land use policy. This municipality has the features of sustainability, mobility, identity, and prosperity. The significant reason for the migration are the high level of insecurity caused by lack of job opportunities, environmental hazard in hilly rural area, lack of basic public infrastructure including education and health facilities. Rampur has also increased population growth rapidly and create challenges for the need of public infrastructure such as road for smooth travel medium for people, urban facilities, and work at the government/public/private institutions. The major findings of this study has anticipated to provide maps that show a synoptic view of urban sprawl growing in the study area. So that urban planning will be integrated land use policy with public infrastructure which will be constructed on the basic demand of the people whom have no access infrastructure planning and its poor facilities in urban planning the municipality area.

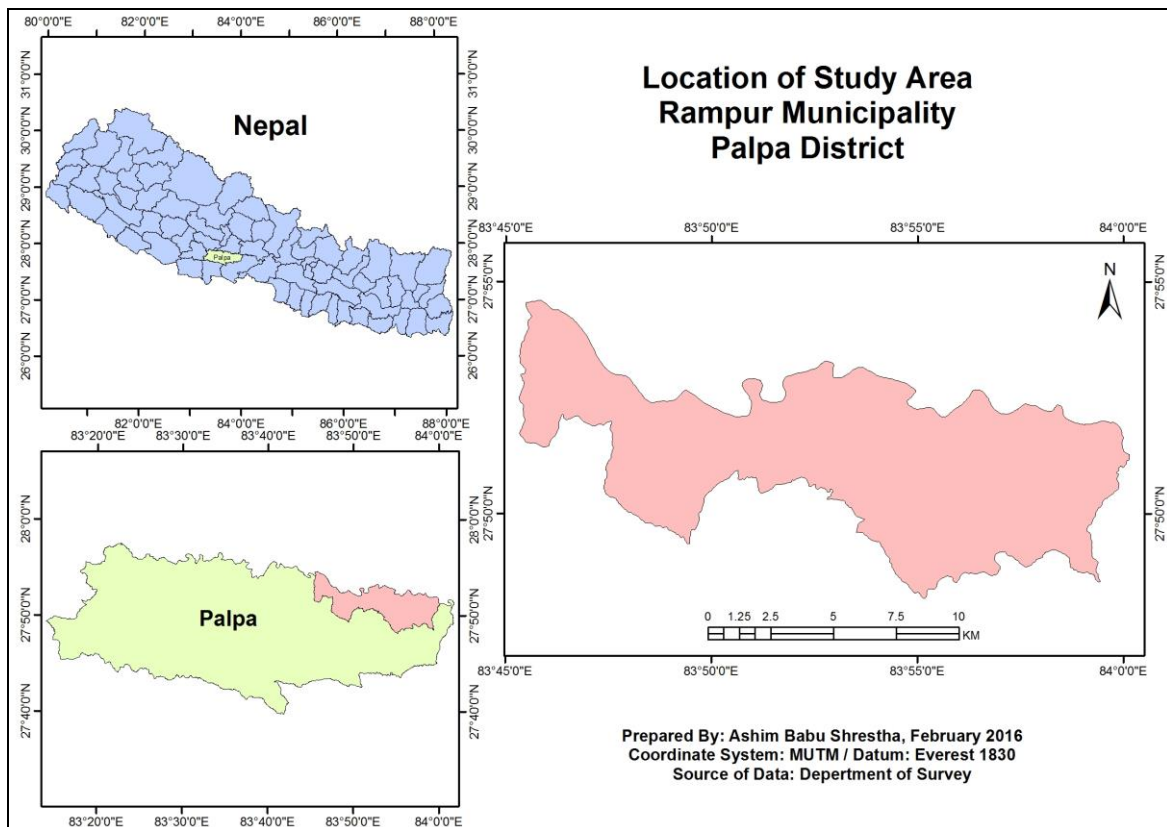
Although urban areas are center of economic development, the trend of urban growth remains the major factor for diminishing valuable natural resources. Therefore, urban land use policy are important for planning and decision making to mitigate the impacts of

urban expansion and attain sustainable for urban development in the municipality. Thus, decision makers can easily recognize land use from these results which are presented in various maps, statistical and graphical presentations. Thus, the urban planning scenario is useful for the decision maker of municipality, and government to prepare an action plan for the sustainable systematic settlement area which fulfills the demand of urban growth and to control the future migration problem in the study area as well as within the Palpa district. It is also helpful to the decision maker for physical infrastructure planning with optimal utilization of natural resources. Planning process is not run in systematic order for sustainable development in Nepal. Everything is haphazardly planned and constructed for development which may create a big issue in near future. In this context, the results from this research are expected to be useful to communities (local people) and Municipality developers, land use planners, researchers, and farmers. The main significance of this research is to identifying the suitable areas for urban development in Rampur municipality Palpa district Nepal.

The VDCs and municipality of Nepal lack proper base map. They are mostly dependent on 1:25,000 or 1:50,000 scale topographic maps, Land resources maps and other available analogue maps which are not sufficient to use for municipality level planning. The available maps do not include the details of municipality and VDC level. These maps are also not much useful for proper decision making process of the urban development activities. Planning process is not run in systematic order for sustainable urban development in Nepal. Everything is haphazardly planned and constructed for development which may create a big issue in near future. In this context, the results from this research are expected to be useful to communities (local people) and Municipality developers, land use planners, researchers, and farmers. Some agriculture and residential area might be covered by cloud so it is difficult to image analysis and image interpretation. The field verification and visual interpretation to solve these problems.

1.3 Study Area

Rampur Municipality is located in northern part of Palpa district. It covers the area of 123.34 sq. km. The municipality is surrounded by Wakamalang VDC in east, Heklang VDC in the west, Chapakot Municipality, Sekam, and Sakhar VDCs of Salyan district and Gajarkot VDC of Tanahu district in the north, and Birkot, Ringneraha, Siluwa, Galdha, Jhirubas and Sahalkot VDCs in the south. It is situated at the altitude 250m to 1850m and $27^{\circ} 48' 9.84''$ to $27^{\circ} 55' 38.32''$ N latitude and $83^{\circ} 39' 23.73''$ to $84^{\circ} 0' 8.57''$ E longitude. The location map of study area Map 1.1 as below.



Map 1.1: Location Map of Study Area

1.4 Literature Review

Review of related studies plays vital role for writing research. In order to make comprehensive, some of the most nearest articles and thesis related to geodatabase, land use land cover and urban development in different countries, municipalities and cities. Review of literature means reviewing research studies of relevant proposition in the related area of the study so that all the past studies, their conclusion and deficiencies may be known and further research can be conducted.

1.4.1 Geodatabase

Geodatabase is an alternative way to store GIS information in one large file, which can contain multiple point, polyline, and polygon layers. Geodatabase is a collection of geographic datasets of various types of common file in single database. Geodatabase is a geographic database hosted inside a relational database management system providing services for managing geographic data such as advanced editing features, validation rules, spatial database relationships, and topological associations. Geodatabase organize geographic data in an efficient manner and allow multiple geographic functions within and between data.

The geodatabase implements smarter behaviors into features, making them realistic to the real world scenarios and easier to edit and manage. The geodatabase features include attribute domains, subtypes, relationship classes, topology, and geometric networks etc. These characteristics were help for data manage, edit, store, and create relationship between GIS features. ArcGIS is geographic information managed the geodatabase. The geodatabase is the native data structure for ArcGIS and primary data format used for editing and data management. The geodatabase is a collection of geographic datasets of various types held in a common file system folder, a Microsoft

Access database, or a multi-user relational database (such as Oracle, Microsoft SQL Server, PostgreSQL, Informix, or IBM DB2). The primary data sets types are: feature classes, raster data and attribute tables (ESRI).

Geodatabase are very important tools to cope efficiently with management and planning of urban areas. The very often cities have been undergoing a fast transformation process, which could result in changing the specific nature of their districts. Digital geodatabase is the complex process involving their digitization in raster or vector format, integration to the geodatabase, publication on the web for online access. (Brumana et al., 2010). Geodatabase model is to be developed for evaluating the environmental quality of urban roads. The environmental quality of the streets is most importance for local communities' especially urban areas. Geodatabase is the core of data well designed and updated in order describe the research area. The study describe about the design and creation of geodatabase of environmental parameters of urban area. Geodatabase enables us to provide a specific and detailed description and analysis of the environmental parameters of urban area. It also observes continuous and update of urban environment. Geodatabase enables users to recover, save and select data based on one or more relations and characteristics. It possess a significant potential for management of spatial data. It protect the data base from illicit actions and provides strict rules that can automatically applied. It offers an interfaces between the database and application programs that are based on logical description (Tsouchlaraki et al., 2010).

Database will be useful for sustainable urban development. Database is designed for thematic layers, entities and topographical relationships. There are various thematic layers which required to prepared geodatabase of urban area. Data are described as point, line polygon and attribute table. The urban development is generally planned for 20-50 years based on the suitability assessment on existing biophysical situation, urban transportation and infrastructure facilities (Oli, 2014).

Geodatabase for Land Use Land Cover and Urban Development

GIS is capable of integrating geospatial data with various sources of information necessary for effective decision making in land use planning and sustainable development. GIS allows planners to perform spatial analysis using its geo-processing and cartographic modelling functions. The geo-processing functions, map overlay is the most useful tool for land use planning and sustainable development of land use activities. GIS database is the input to modelling and analysis programs together with data and other database for analysis and mapping. It has been used to information retrieve, development, control, mapping, site selection, land use planning, land capability mapping, land suitability analysis, monitoring and decision making.

Sustainable land use meets the needs of the present while conserving resources for future generations. Land use planning to achieve the goals of use of information, appropriate technology and sustainable decision making. Effective land use planning to benefits the local communities, regional level, and national level. Effective land use planning includes information management through GIS, computer simulation, and spatial temporal data modelling on present land use. Land use planning is become complex and multidisciplinary as planner face multiple problems that need to be addressed within the planning framework. The problems of land use planning are pollution, ecosystem deterioration, global warming, poverty, unemployment, deforestation, desertification, farmland deterioration, and low economic growth. Geodatabase more useful for land use land cover and land use planning, map updating and future used.

1.4.2 Land Use Land Cover

Land represents one of the major natural resource available for Nepal. More than 90% of the country population depends on land for their basic need like as food, fuel and timber.

Nepal has been divided into three physiographic regions i.e. Lowland (Terai), Middle Hills and High Mountains. The major land use land cover categories of the (Middle Hills) Rampur municipality are Agriculture, Commercial, Forest, Industrial, Public Use, Residential, Road and Water Bodies.

Urban growth and land use study is the very useful in local government as well as the urban developer for the appropriate plans of urban development. Land use provides for the developer and decision makers, the required information about the current state of development and the nature of changes that have occurred, physical conditions, public service accessibility, economic opportunities, local market, population growth, political situation, and government plans and policies are the driving forces of urban development process.

GIS is considered as a design making tool in problem solving environment. Spatial analysis is a vital part of GIS and can be used for many applications like site suitability, productivity, natural resource monitoring, environmental disaster management and many more. The present land use pattern of the municipality under study is classified using remotely sensed image with the help of ground based information. Lack of clear guidelines on the classification system has posed a level of difficulty in assigning the classes of different hierarchy in land use categories. Hierarchical classification system helped in incorporation of complex land use pattern of this municipality. The land use classes yield better accuracy because the classes are designated manually based on ground knowledge and visual interpretation and digitization rather than supervisor classification. These land use data and map can be used to formulate land use and other plans for the municipality under study. Further it can also be used for management activities and regulating land use activities in the Rampur municipality.

Land use and land cover change analysis is an important tool to assess changes on a global scale at various spatial and temporal scales. Urban expansion of Dhaka metropolitan is the major cause of reduction of wetland, cultivated land, and vegetation and water bodies. Land use and land cover classification derived from topographic maps are increased from 11% to 33.4% which leads to quick loss of rural arable lands and fast increase of population through migration from rural to urban. Rapid growth of population impacts on water bodies, cultivated lands, vegetable and wetland reduces. Informal settlement creates the risk of environmental impairments (Dewan and Yamaguchi, 2008). As an effect of urban expansion, GIS and remote sensing has been applied to assess the land surface temperature. Environmental factor is the main cause of changes on urban. The map of the study area is produced by supervised classification of image in different time. This study provides better methodology of population and subsequent urban development. The extent of urbanization is one of the potential threats to environment for utilization of land resources and urban planning. To meet the rising demands of human and welfare, land use and land cover is most advantages for selection, implementation and planning (Dolui, Das and Satpathy, 2014). Land use development has become an important task for increasing awareness of land resource conservation. Due to increasing population and economic growth, human activities have impacts on land use. Furthermore growing demand for urbanization impact on land resources. Rational and sustainable decision based on land use suitability assessment which is a great issue of government and land user as well. Basically land use suitability assessment which is a great issue of government and land user as well (Chen, 2014).

Land is the human use of land involving the management and modification of natural environment or wilderness into built environment such as fields, pastures, and settlements. It is used to describe human uses of the land, or immediate actions modifying or converting land cover. It includes such broad categories as human settlements, irrigated and rain fed fields, agriculture, national parks and transportation

and other infrastructure. Land use determines how we have to act, how and where we live, where we work, where the services are and how much we need space for these functions.

Land cover refers to the vegetation, water, bare rock, sand and similar surface and man-made construction occur on the earth's surface. While land use refers to a series of operations on land, carried out by humans, obtain of products and benefits of using land resources like as soil resources and vegetation resources are the part of land cover (DeBie et. al., 1996). Land use and land cover are distinct yet closely linked characteristics of the earth's surface. The use of land could range agriculture, urban development, logging and mining among many others. While land covers categories could be cropland, forest, wetland, pasture, roads, urban areas among many others. The term of land cover to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usages to include other things such as human structures, soil types, biodiversity, surface and ground water (Mayer, 1995).

Land cover is the physical material at the surface of the earth. Land cover includes grass, forest, trees, bare ground, water, etc. there are two primary methods for capturing information on land cover: field survey and analysis of remotely sensed imagery. Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and artificial structures (Ellis, 2010). Land cover is one of the key environmental variables for global change studies. It is important for global scale land use planning in order to continue food supply for human and animals as well as sustainable environment. Land cover is one of the main features of the terrestrial environment which can be extracted by remote sensing technique.

GIS and RS application in Land Use Land Cover

The spatial and temporal dimensions are major concern of GIS and remote sensing. Remote sensing can be used to acquire spatial temporal series of geographical data and to perform LULC change analysis. Obtained data can be processed using geographical information system (GIS) techniques and varied modelling approaches thus providing. Urban growth remains one of the major topic concerning GIS and remote sensing applications. Remote sensing and GIS have proved to be effective means for extracting and processing varied resolutions of spatial information for monitoring urban growth (Masser, 2001).

GIS and remote sensing techniques provides invaluable information of changes and process in the LULC and can play a vital role in providing accurate and reliable LULC detail with lower cost and laser time compared to other methods and technologies. Recent improvements in satellite image quality and availability have made it possible to perform image analysis at much larger scale than in the past. This is likely lead to a much wider used of satellite imagery at the regional level as a reliable source of timely and accurate spatial data. In recent years, GIS technologies have greatly increased the capability to model and map making system and remote sensing technology can play a vital role in providing accurate and reliable LULC details with lower cost and lesser time compared to other methods.

1.4.3 Urban Development

Land use must be economically viable, so one goal of land development planning is to make efficient and productive use of the land. For any particular land use, certain areas are suited than others. Efficiency is archived by matching different land uses with the areas that will yield the greatest benefits at the least cost.

Current trend of planning in developing countries have shown that long range projection of plans and end state allocation of land use may fail due to the error in decision-making due to unforeseen changes in economic or social conditions. It is required to have a holistic regional development strategy in perspective and have both long as well as short range goals integrated in a planning process itself is in a continuous state of flux. The intermediate evaluator steps seek to refine and at times redefine the long range planning goals to meet the current demands and at the same time making the development sustainable.

Urbanization creates high demand of land mainly for residential, commercial, and industrial etc. this growth associated with increasing pressure on land for settlement. As a result of that ecologically valuable lands are converted into urban development. However GIS is important tool for land planners to make land development process more attractive and efficient. GIS provide information to support complex decision making. GIS is a technique which provide greater accuracy and flexibility for land use planning (Weerakoon, 2002). The availability of urban land cover data is critical for town planners and policy maker. Metropolitan areas are changes continually over time and local government must be able to update database to land use. Urbanization is an idea, progressive concentrative of population. High rate of urban population growth is a cause of urban and town planners for efficient planning. GIS helps us to analysis the data spatially, are dealing, and optimize planning process. Remote Sensing and GIS helps to extract urban land cover information. GIS needs to be explored for land use transportation models network analysis, simulation of urban activities (Rai, and Kumra, 2011). GIS tool and multi-criteria evaluation (MCE) techniques are used for selection of suitable sites for urban development of hill town. In this research six factors are identified like slope, road proximity, land use, land values, soil and geomorphology for evaluation criteria. The thematic information layers are generated by using visual interpretation of satellite data for variable displaying site suitability measured (Kumar and Kumar, 2014).

Rampur municipality is the moderate suitable area for urban development of Palpa district. There are two major fault along the Kaligandaki River and foot of the hills in the south and minor faults along the streams and north of foot hills. According to the facilities of land resources and others facilities like drinking water, irrigation water, touristic places, Kaligandaki River basin, population growth, community forestry, modern agriculture facility, road access, banking access resources etc. are the best for urban development.

Urban development is the process of decision making for the sustainable management of resources activities. The main purpose of the urban development for the needs of community while balance to uses of land and natural resources. Urban development achieve a type of land use, which is sustainable, socially and environmentally compatible, social desirable and economical sound. Urban development should be decision making process that facilitates the allocation of land to the uses that provide the greatest sustainable benefits.

The main purpose of urban development of Rampur municipality as below;

- To control the haphazard urbanization of Rampur municipality.
- To use the sustainable and management of land use activities.
- To increase of environmental destruction is to be counteracted.
- To settled the land use conflicts.
- To mitigate the negative effects of land use.
- To enhance the efficient use of natural resources with minimum impact on future generations.
- To minimize the conflicts of land use for future generations.
- To meet the needs of people while safeguarding future resources.
- To develop a plan for efficiency, equity and sustainability.

Theoretically, the primary purpose of planning is to separate land uses that are thought to be incompatible to each other. In practice, planning is used to prevent new development from interfering with existing residents or businesses and to preserve the "character" of a community. Planning is commonly controlled by local governments such as municipalities or villages, though the nature of the planning regime may be determined or limited by state or national planning authorities or through enabling legislation. In Australia, land under the control of the Commonwealth (federal) government is not subject to state planning controls. The US and other federal countries are similar. Urban planning in France and Germany are regulated by national or federal codes. A planning map is a graphic depiction of the boundaries for which a certain set of standards or regulations have been adopted by a government entity. The planning map typically provides predictability for the residents and development community as to what type of land uses may be expected and allowed within each VDC, Municipality, and District.

GIS and RS Application in Urban Development

A GIS can provide better information to support different type of complex decision making. With rapid advancements taking place in computer hardware and GIS software, more complex models are being developed. These models help researchers to simplify complex systems and to develop theory to understand the process at work better.

Urban development is to make decisions about the use of land and resources. It is important in highly populated communities primarily due to conflicts between competing users and interests of users. The planning activities are tailored to make optimal use of limited land and resources. GIS is a computer based system that is used to store and manipulate geographic information. The GIS consists of a spatial components represented by points, lines, and polygons and attributes data that describes characteristics of the spatial features. GIS and remote sensing is primarily used in the

development of spatial database and land use process that determining the suitability and sustainability of urban development. Land use data is important part of spatial infrastructure for Nepal. Some good quality decisions for planning requires that the quality data be available at hand. Remote sensing technology can be used to create thematic maps using variety of image classification techniques (Paudyal et al., 1992). Thematic maps provide for identification and mapping of all important LULC types present in the area. Land use maps will also provide a baseline for urban development. Remote sensing allows frequent updates of the land use maps thus providing for a valuable currency useful for urban development.

1.5 Objectives of the Study

The main objectives of this research is to identify the areas suitable for urban development of Rampur Municipality, Palpa.

The sub - objectives are;

1. To develop structure of geodatabase of the study area.
2. To analyse land use land cover of the study area 2015.
3. To identify the areas suitable for urban development.

1.6 Structure of the Thesis

This research thesis is organized in four chapters.

Chapter: I

First chapter deals with background of the study, objective, research problem, study area, research problem and motivation, structure of research, concept of the geodatabase, geodatabase for land use land cover and urban development, LULC, GIS and RS application in land use land cover and urban development. This chapter include related

case study of the literature review in geodatabase, land use land cover, and urban development and conclusion.

Chapter: II

The second chapter describe on data source and data types, software used, research methodology, suitability criteria for urban development, satellite image processing, visual interpretation and digitization, procedure used and weighted overlay analysis.

Chapter: III

The third chapter describes the geodatabase, types of geodatabase, concept modeling of database, database and geodatabase structures, land use land cover, classification system and criteria, LULC class and description, present LULC, suitable analysis for identifying suitable areas, suitable areas for urban development, result analysis and conclusion.

Chapter: IV

The fourth chapter describes the summary, conclusions, and recommendations of the research.

Chapter- 2: Methodology

2.1 Data Types and Data Sources

The Topographical Maps of the Study area are covered under 2880 04D, 08A, 08B, 08C, 01C, 05A, 05C in the scale of 1: 25,000 scale bearing supplementary contour of interval 10m. These maps are published in 1996 and are compiled from 1: 50,000 scale aerial photography of December, 1990 and field verification done in December, 1991. The Topographical Maps were used for planning process of GCPs collection with DGPS survey and also used for feature extraction of dataset such as Municipality boundary, location name, and additional data for GIS based analysis. The list of data types and sources as below in Table 2.1.

Table 2.1: Data Types and Sources

Data Type	Year	Scale / Resolution	Source
Topographical Map and digital layers	1996	1:25000	Department of Survey, ERMC, free of cost
Geology Map	1978/79	1:125000	Department of Survey, Nominal Cost Price
Satellite Image Digital Globe 4 Band Panchromatic and Multispectral	March 07, 2015	1m PAN and 2m MSS	National Land Use Project, free of cost
Aster DEM	2011		Download from USGS Website, Free of Cost
DGPS Survey for GCPs and Field visits and field verification	2015	Boundary, Land Use etc	ERMC team with me, free of cost

2.2 Software Used

The images were processed in ERDAS and GIS software programs to get required analysis and mapping results. They are ArcGIS 10.2, ERDAS IMAGINE 11 and Microsoft Office 2013

2.3 Research Methodology

The thesis research work is basically spatial data preparation from the high resolution satellite image by visual image interpretation method. The geodatabase was prepared for future used and updating spatial data. The suitability analysis and weighted overlay analysis is the specific approaches and methods adopted to identifying the suitable areas for urban development of the study area. The work flow diagram in Figure 2.1 as below.

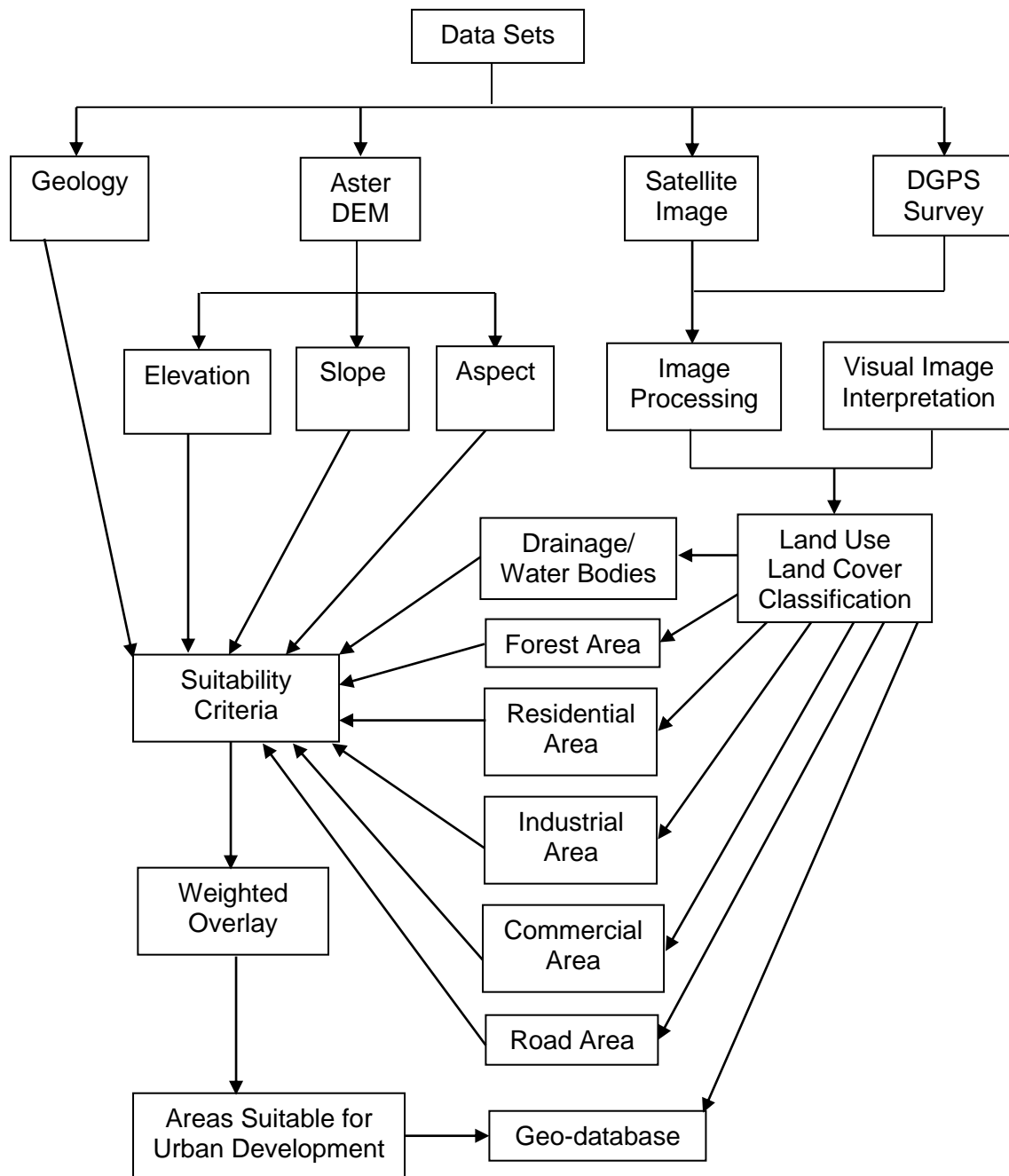


Figure 2.1: Work Flow Diagram of Research Methodology

2.4 Suitability Criteria for Urban Development

The urban development carried out on the basis of GIS based spatial analysis using weighted overlay analysis on several available data sets. The data files comprised the various parameters like slope, elevation, aspect, drainage/water bodies, land use land cover, and other necessary parameters used for identifying the areas for suitable for urban development. A rule base was developed by using multiple-criteria on the basis of research knowledge for land use planning. These criteria were used to identifying a suitable areas for urban development area. The ArcGIS 10.2 software was used for GIS analysis.

The process for identifying the suitable areas map begins with ensuring all data are in the appropriate raster format. The stream line shapefiles were converted to raster files displaying distances from line features up to meter using the Euclidean Distance tool. The polygon shapefiles such as geology buffer, forest area buffer, drainage/water bodies buffer, residential area buffer, commercial area buffer, industrial area buffer and road area buffer should be converted from vector to raster using Feature to raster tool. A slope raster was created using the elevation raster using spatial analyst tool. All raster files should be reclassified using reclassify tool. The appropriate distance values were binned into four classes based on Table 2.2 and favorability values were assigned. The all criteria types (1-4) elevation and slope raster were assigned to correct favorability classes, which is started were: 1= not suitable, 2= least suitable, 3= moderately suitable, and 4= highly suitable. All reclassified raster were added as inputs in the weighted overlay tool. This resulted in a final suitability raster for suitable areas for urban development final map production.

Table 2.2: Weight for Identifying the Areas Suitable for Residential, Commercial and Industrial Development in Rampur Municipality, Palpa District, Nepal

S. N.	Category	Criteria	Value	Suitability Level
1.	Geology	Unconsolidated Sediments	4	Highly Suitable
		Sallyan Series	3	Moderately Suitable
		Midland Metasediments Group	2	Least Suitable
		Thrust Buffer 100m	1	Not suitable
2.	Elevation	< 500m	4	Highly Suitable
		500 – 750m	3	Moderately Suitable
		750 – 1000m	2	Least Suitable
		> 1000m	1	Not Suitable
3.	Slope	0 – 10 Degree	4	Highly Suitable
		10 – 20 Degree	3	Moderately Suitable
		20 – 30 Degree	2	Least Suitable
		> 30 Degrees	1	Not Suitable
4.	Aspect	157.5 – 202.5	4	Highly Suitable
		112.5 – 157.5 and 202.5 – 247.5	3	Moderately Suitable
		90 – 112.5 and 247.5 - 270	2	Least Suitable
		0 – 90 and 270 - 360	1	Not Suitable
5.	LULC	Agriculture	4	Highly Suitable
		Buffer of Forest 100m, River 40m, Stream 20m, Commercial 20m, Residential 20m, Public Use 20m, Industrial 20m and Road 20m	1	Not Suitable

2.5 Satellite Image Processing

Rectification of the imagery consists of the geometrical, radiometric aspects. The description of digital image pre-processing of radiometric correction and geometric correction as below;

2.5.1 Radiometric Correction

Firstly, the images are radiometrically corrected in which basically we focus in the sun angle correction and haze correction. However, we could not ascertain about the Skylight correction from the very beginning as it can be only said after the observation of the actual dataset and other acquisition parameters (date and time of day of the observation, type of the satellite imagery itself etc.).

2.5.2 Geometric Correction

After the application of radiometric correction, apply the geometric correction of the satellite imagery where it is geo-referenced and re-sampled. In order to improve the geometric accuracy of the original RPCs, these has to be corrected using GCP collected from ground survey technique of DGPS survey and geometric adjustment has done using least square adjustment with affine transformation for estimate the error occurring between the satellite scene and the reference scene. The corrected image coordinates are computed based on the affine transformation and given by;

$$\text{row} = a_0 + a_1 \cdot \text{rpcr} + a_2 \cdot \text{rpcc}$$

$$\text{col} = b_0 + b_1 \cdot \text{rpcr} + b_2 \cdot \text{rpcc}$$

Where rpcr and rpcc are the originally rational polynomial coefficients provided by satellite image provider or vendors. The RPCs mathematical model are widely used for geo-referencing the images (Lehner, Muller and Reinartz, 2005). The present project used geometric correction of satellite images using RPCs mathematical model with RPCs file and GCPs collected with DGPS technique in national co-ordinate system as reference co-ordinate system. The coordinate system used is as prescribed by National Map Projection and Coordinate System by the Department of Survey with the following parameters Table 2.3.

Table 2.3: Projection System

Parameters	Value/reference
Projection	Modified Universal Transverse Mercator (MUTM)
Spheroid	Everest (1830)
Datum	Everest (1830)
Semi major axis (a)	6377276.345
Semi minor axis (b)	6356075.413
Inverse flattening (1/f)	300.8017
False Coordinate	500000 m Easting, 0 m Northing
Central meridian	84° E Longitude, 0° N Latitude (Equator)
Scale factor	0.9999 at Central Meridian

2.5.3 Visualization of different Color Composite

Enhancing of the spatial resolution was carried out by fusing of the multi-spectral images among themselves (i.e. generating color composite). In this way, Intensity of panchromatic image is utilized to get the better detail view. As the date and time of the acquisition of these two sets of satellite imagery do not vary that much, we also conducted the image fusion. The process is conducted in the ERDAS Imagine software.

2.5.4 Pan-sharpening

Pan-sharpening (resolution merge or image fusion) technique has used to create a high resolution multispectral data set by the fusion process of high resolution panchromatic data with lower resolution multispectral data. For this research, the pan-sharpening was carried using Brovey transform to visually increase contrast in the low and high ends of an image's histogram. Pan-sharpening was done using multiplicative technique to increase presence of the intensity component and involved in urban or suburban studies, city planning, and utilities routing roads and cultural features (which tend toward high reflection) to be pronounced in the image.

2.6 Visual Interpretation and Digitization

Visual interpretation is the process of identification and classification of land cover classification. Most intuitive way to extract information from the satellite imagery is visual image interpretation (Tempfli, Bakker, and Kar, 2001). Visual image interpretation assisted by extensive field visit was used to derive the LULC classes from the imagery. Interpretation elements such as tone, texture, shape, size, pattern, site and association were used for digitizing, editing and assigning land use classes. The size of an object is one of the most distinguishing characteristics and one of the most important elements of

image interpretation. Many natural and man-made features on the ground have very unique shapes that can be referenced in photo and image interpretation.

The process was conducted using in the ERDAS Imagine software. Theory has already been established in the context of the result of the satellite imagery. Since spectral information based classification renders mixed result, it was found not suitable to directly use as the basis for the land use mapping. Subjective judgment is always essential over this result. Therefore, multiple image processing techniques were performed to extract the information from the satellite imagery. Subsets of information were extracted from one type of processed product whereas the other subsets were extracted from the other product. The Classified image did not render the result better that would be captured through the visual interpretation of the images.

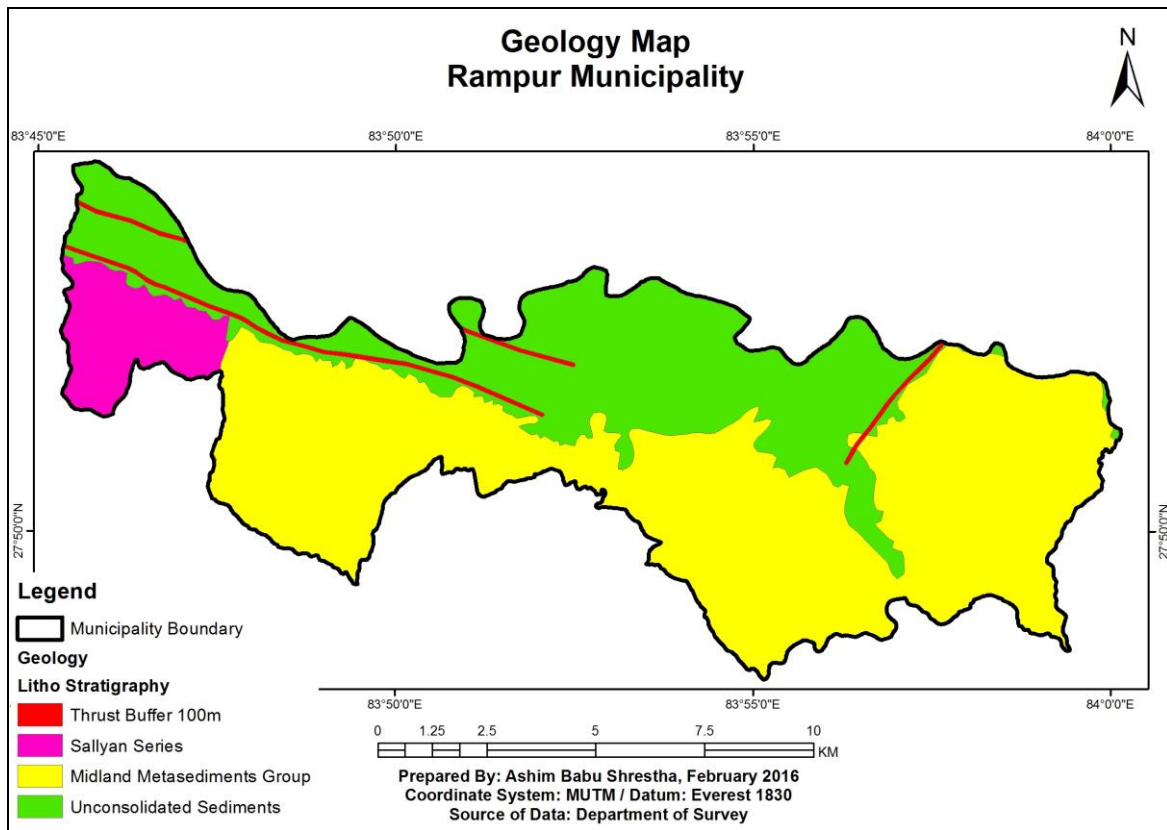
2.7 Procedure

The multi-criteria analysis and analytic hierarchy process used for identifying the suitable areas for urban development. In this research, the five subjective criteria were used for urban development area selection. These five subjective criteria are geology, elevation, slope, drainage/water bodies, and LULC description with map as below.

2.7.1 Geology

Rampur Municipality of Palpa district is mainly composed of red soil and clay in the Lesser Himalaya. Geologically, it has 1) recent and Pleistocene formation by alluvium, the work of water including river terraces. It also has 2 major fault along the Kaligandaki River and foot of the hills in the south 2) Southern Part of the area consists of Precambrian to recent Cambrian with Jarbutta formation with shale and lime stones. In this research geological data has been used for the analysis of terrain and slop of study area which is

helpful for the analysis of urban planning at present and future urban development. In the base of geological map study identified the suitable area of urbanization and other infrastructure development. According to the analysis thrust area is identified which is support for the development process. The Geology Map 2.1 as below.



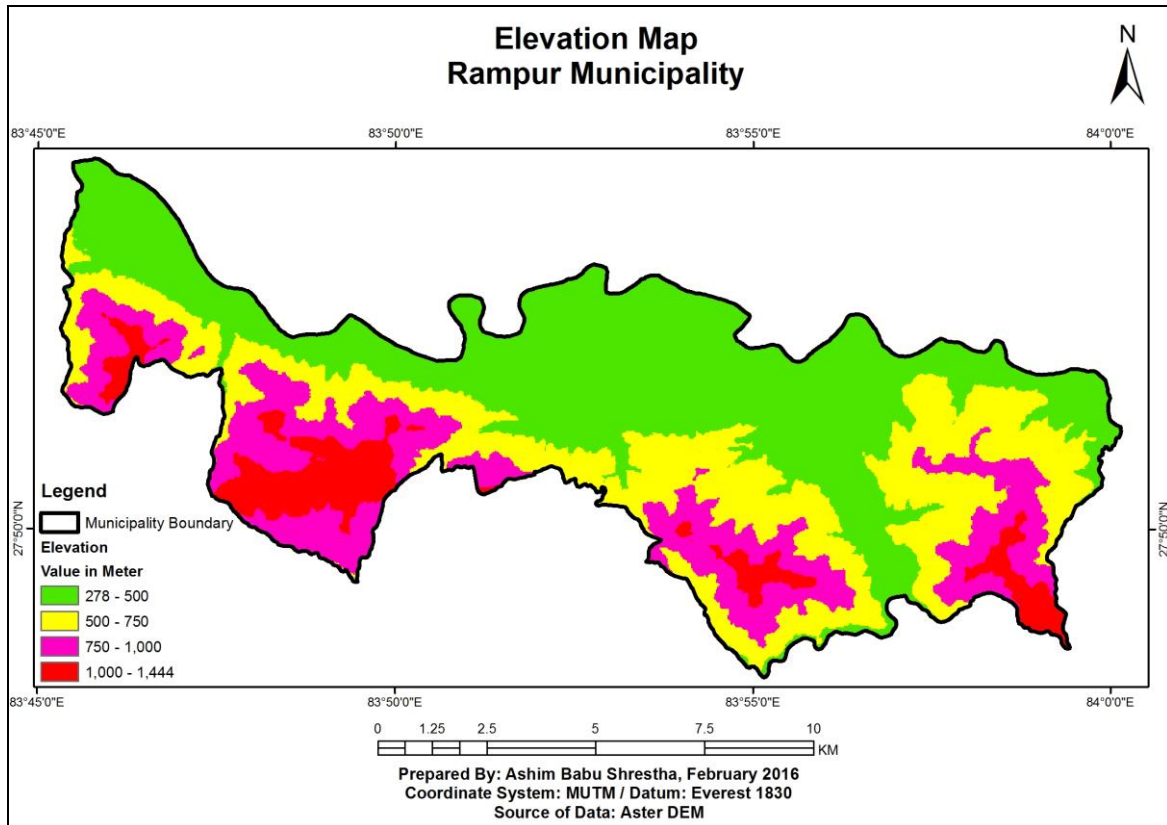
Map 2.1: Geology Map

2.7.2 Elevation

The elevation will show the elevation situation of the Rampur municipality. Almost all the area of Rampur falls under the sloping land. Elevation of this municipality ranges at the altitude 250m to 1850m above mean sea level. There are four class of elevation i.e. < 500m, 500m – 750m, 750m – 1000m and > 1000m. The elevation of < 500m is useful for residential, commercial, and industrial identifying suitable areas for urban development. The < 500m is highly suitable areas for urban development and it gives the high weight

and > 1000m is not suitable for urban areas so it gives the low value for planning criteria.

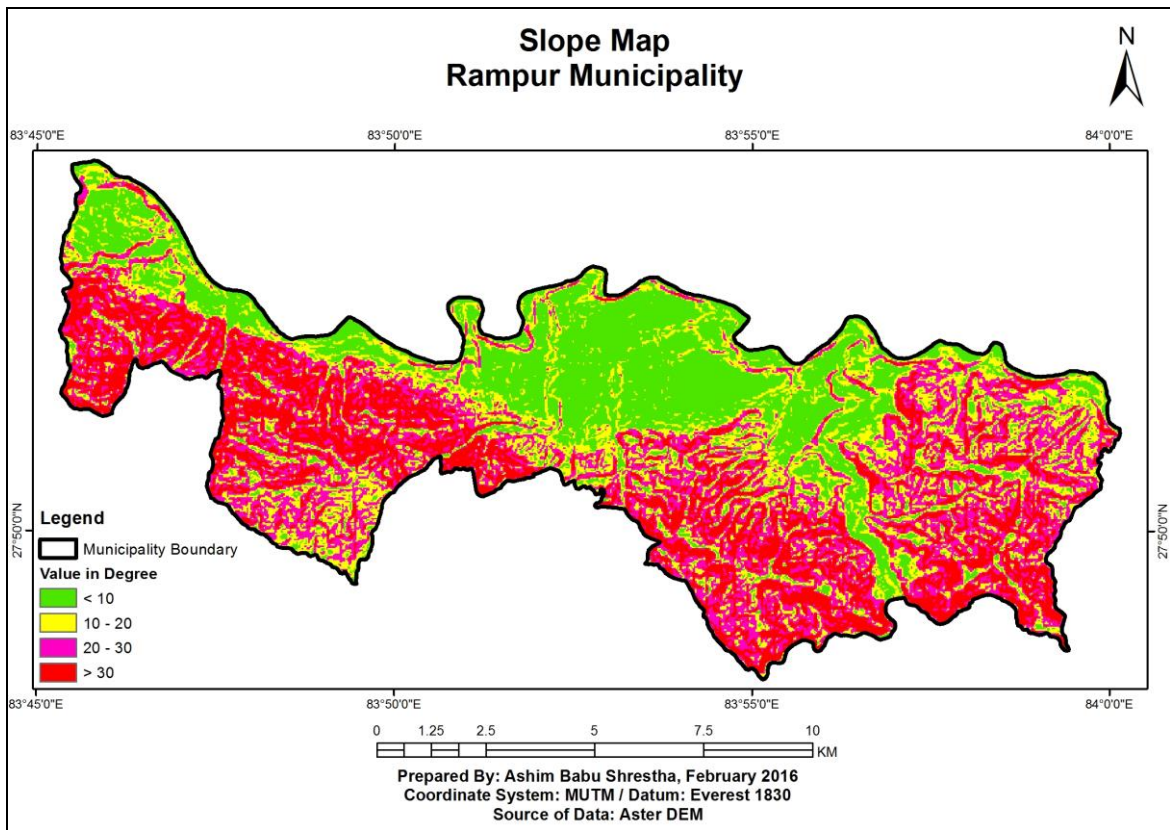
The elevation situation of Rampur municipality Elevation Map 2.2 as below.



Map 2.2: Elevation Map

2.7.3 Slope

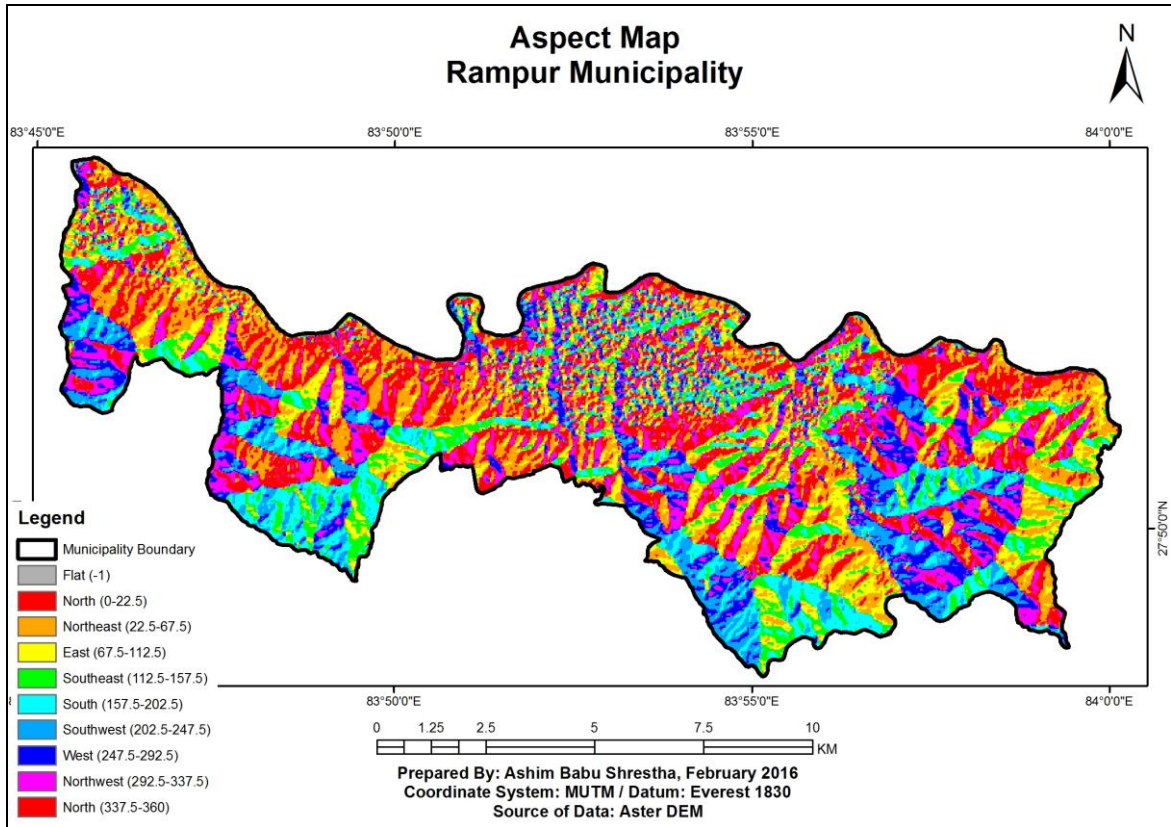
The terrain of middle hill of Rampur municipality is flat to very steep. The slope degree ($^{\circ}$) of this municipality is 0° to 84° . There are four class of slope i.e. $0^{\circ} - 10^{\circ}$, $10^{\circ} - 20^{\circ}$, $20^{\circ} - 30^{\circ}$ and the maximum gradient is 30° and above. The slope of $0^{\circ} - 10^{\circ}$ is more useful for residential, commercial and industrial areas suitable for urban development. The $> 30^{\circ}$ slope is not suitable for planning. The suitable area slope is high weight value and not suitable areas for low weight value. The Slope Map 2.3 as below.



Map 2.3: Slope Map

2.7.4 Aspect

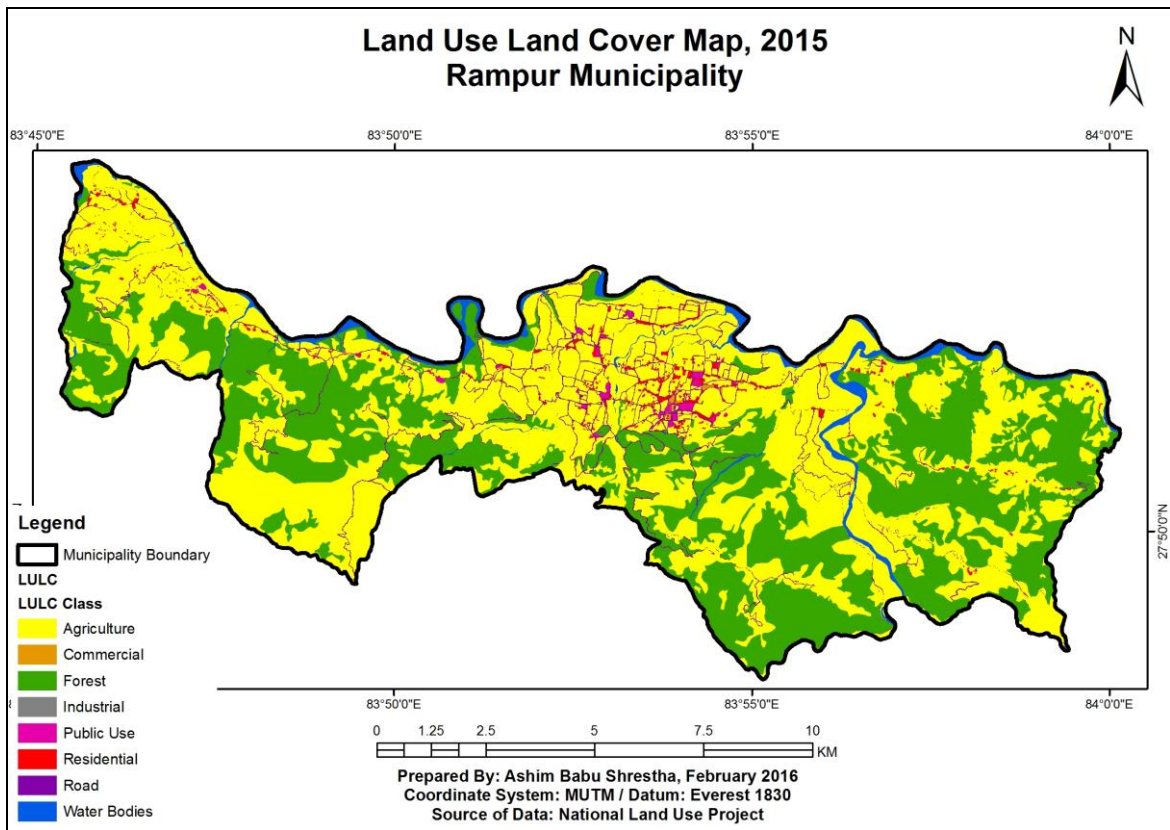
Aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. Aspect can be thought of as the slope direction. The values of the output raster will be the compass direction of the aspect (ArcGIS ESRI, 2016). Aspect is better for urban development as a face of East or South direction according to sun light direction. Sun always rise from East direction and set in West direction. According to the sun light direction East and South face sufficient light for winter season. North face very poor light so it is always cold. So, South direction is highly suitable i.e. high weight and North direction not suitable i.e. less weight. The Aspect Map 2.4 as below.



Map 2.4: Aspect Map

2.7.5 Land Use Land Cover

The land use land cover map is the basic criteria for identifying suitable areas for urban development. The criteria parameters as geology buffer, forest area buffer, drainage/ water bodies buffer, existing residential area buffer, existing commercial area buffer, existing industrial area buffer and existing road area buffer are not suitable for urban development. The Land Use Land Cover Map 2.5 as below.



Map 2.5: Land Use Land Cover Map

2.8 Weighted Overlay Analysis

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis (ESRI, 2015). Weighted overlay only accepts raster input such as geology, elevation, slope, aspect, and LULC in this research. The raster is required reclassified before they can be used. The values of raster are grouped into ranges must be assigned a single value before it can be used in weighted overlay tool. The assign weights at the time of reclassifying the cells in the raster will already be set according to suitability. The output raster can be weighted by importance and added to produce an output raster using weighted overlay tool using in ArcGIS. The tool was used for to locate suitable areas, higher values generally indicate that a location is more suitable.

The steps for running the weighted overlay tool

The steps for running the weighted overlay tool are as follows:

1. Select an evaluation scale
2. Add input rasters
3. Set scale values
4. Assign weights to input rasters
5. Run the weighted overlay tool

2.9 Conclusion

The research methodology are established in this chapter. This chapter outline the study area, data types and sources, software used, research methodology, and data processing. The required map as geology, elevation, slope, aspect, drainage/water bodies, and land use land cover map ware prepared in this chapter which is required for criteria of identifying suitable areas for urban development. The data types and data sources collected by department of survey and national land use project.

Chapter- 3: Process and Result

3.1 Geodatabase

A database is a lot of information stored in a computer device, taking into account the existing technologies used to organize and structure the database, so we can easily manipulate the content. A database is collection of data organized in a structured way, so that; information can be retrieved quickly and reliably (Closa et al., 2010). The invention of information technology has led the database to be used in a management system, which is called database management system. A database management system is a set of programs that enables the management and access to a database. It generally hosts multiple database, which are designed with various software by themes.

The geodatabase is the common data storage and management framework for ArcGIS. It is a container for spatial and attribute data. A geodatabase is more than a collection of datasets. The multiple meaning of geodatabase in ArcGIS as below.

- The geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and data management. While ArcGIS works with geographic information in numerous geographic information system (GIS) file formats, it is designed to work with and leverage the capabilities of the geodatabase.
- It is the physical store of geographic information, primarily using a database management system (DBMS) or file system. You can access and work with this physical instance of your collection of datasets either through ArcGIS or through a database management system using SQL.
- Geodatabases have a comprehensive information model for representing and managing geographic information. This comprehensive information model is implemented as a series of tables holding feature classes, raster datasets, and attributes. In addition, advanced GIS data objects add GIS behavior; rules for

managing spatial integrity; and tools for working with numerous spatial relationships of the core features, rasters, and attributes.

- Geodatabase software logic provides the common application logic used throughout ArcGIS for accessing and working with all geographic data in a variety of files and formats. This supports working with the geodatabase, and it includes working with shapefiles, computer-aided drafting (CAD) files, triangulated irregular networks (TINs), grids, CAD data, imagery, Geography Markup Language (GML) files, and numerous other GIS data sources.
- Geodatabases have a transaction model for managing GIS data workflows.

The geodatabase design and structure from ESRI as below Figure 3.1.

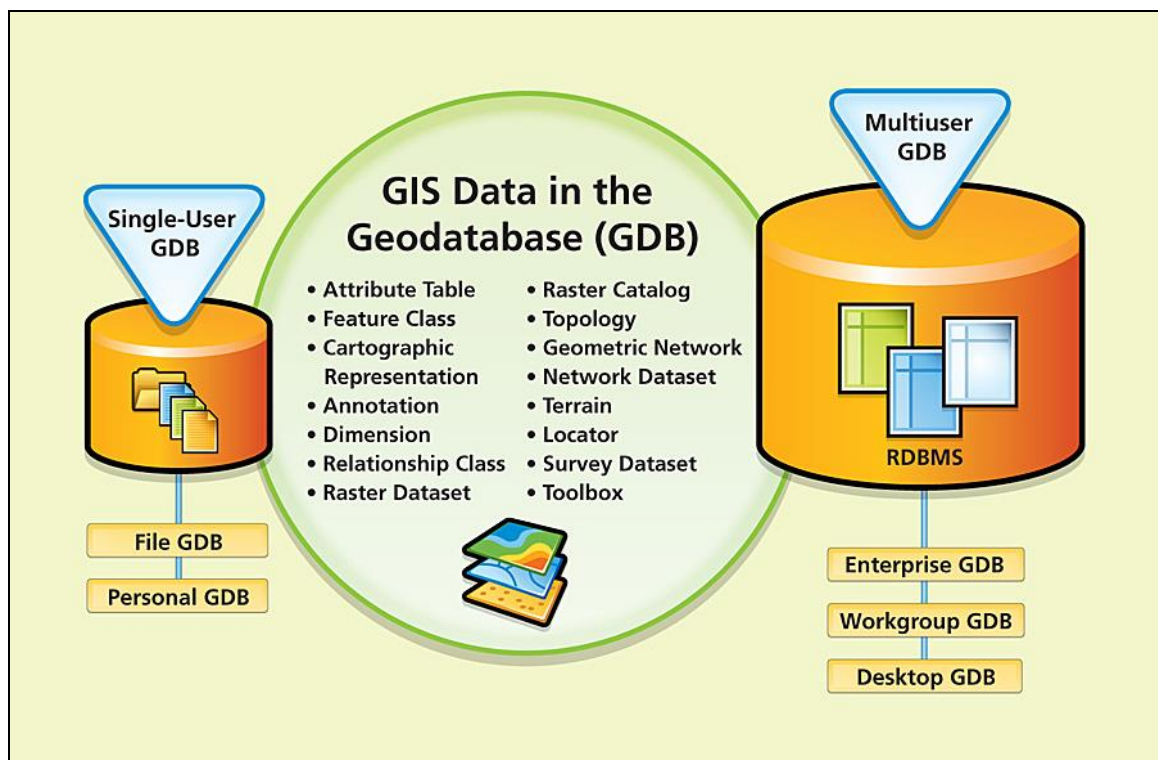


Figure 3.1: GIS Data in the Geodatabase (Source: ESRI)

Modern GIS users spatial database to integrate the geometry or features data with other types of data (Yeung and Hall, 2007). Spatial database facilities strong and querying data that is related to objects in space, including points, lines and polygons. Other typical

database can understand various numeric and character types of data, while, spatial databases need additional supports to process spatial data in the form of geometry or feature. Spatial data, which is also called geographical data, focuses cartographic or mapping perspectives.

3.2 Types of Geodatabase

There are three types of ESRI Geodatabase. The short description of geodatabase as below;

1. **The File Geodatabase:** Dataset can weigh up to 1T. This database can be encrypted and secured.
2. **The Personal Geodatabase:** The data is stored in an access database. The maximum size of this database is 250 to 500 MB.
3. **The ArcSDE Geodatabase:** The data is stored in external databases and much more cumbersome to manage but also more efficient as Oracle, DB2, SQL Server.

The geodatabase can contain classes of entities (feature class), sets feature classes (feature dataset), and classes of objects (object class) also called tables and raster files. A (feature class) is a homogeneous set of entities that have the same geometry (point, line, and polygon) and the same attributes. These attributes are stored in the table of the (feature class). The notation of class of entities is similar to the concept of file (shapefile) formats. A table can be stored in a geodatabase it is characterized by a set of fields and records. The tables of a geodatabase can be linked or attached in same time to tables or features classes.

3.3 Conceptual Modeling of Database

Model as a simplification of reality and defined the reason for modeling as to better understand the system (Booch et al., 1999). Also they outlined four aims to be achieved through modeling systems;

- Visualization of a system as it is or as we intend it to be.
- Specification of the structure or behavior of a system.
- Models provide a temple for guidance while constructing a system.
- Documentation of decisions made during the design process.

Database modeling in the software system has similar consideration abstraction of the essential elements of the observed reality from nonessential elements (Lisbao Filho and lochpe, 2008). A conceptual database modeling describes possible data content, structures and constraints applicable to them. Like other models, to express the database modeling descriptions in a convenient way, conceptual data modeling language is used. A conceptual data modeling language is used of formal expressions of tools and techniques used for data modeling.

According to the (Yeung and Hall, 2007) different modeling techniques used for database management systems can be classified in the following categories.

1. Hierarchical Systems
2. Network Systems
3. Relational Systems
4. Object-oriented Systems

According to the (Hoffer and McFadden, 2002), the two common approaches for data modeling are the entity relationship model and the object oriented model. The basic component of the entity relationship model are entities, relationship, and attributes. An

entity is an object event or concept in the user environment about which is maintained. A relationship is a meaningful association between entities. Object oriented modeling represents the world as object class. Object class are similar to entities in the entity relationship model but in addition to having an attributes and relationships. Also, they exhibit behavior, which is represents how the object acts and reacts to events.

3.4 Database and Geodatabase Structures

A physical database object class are tables and attributes are columns in the table. An object is row in the table (object class), thus all objects in an object class have similar attributes. The database structures: classes, objects, and attributes demonstrates the figure as below Figure 3.2.

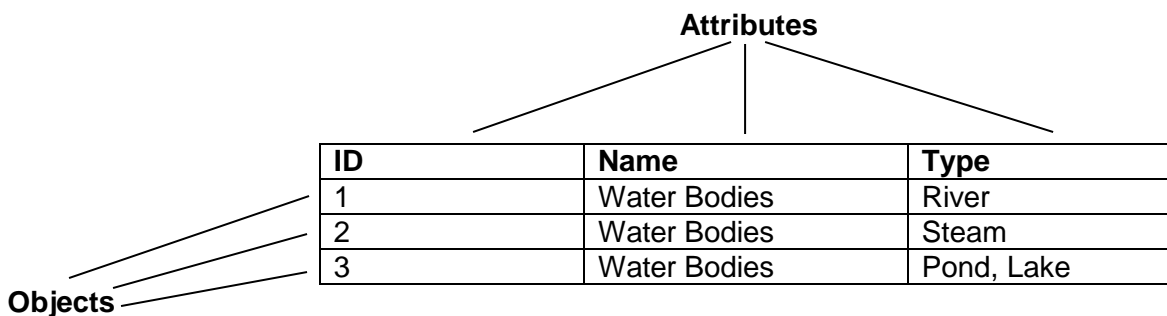


Figure 3.2: Database Structures: Classes, Objects, and Attributes

Geospatial database are distinct from other information systems by their capability to store spatial information using spatial classes and objects. The ArcGIS geodatabase is a physical store of geographical information inside a database management system (ESRI, 2003). The geodatabase spatial classes called feature classes and the shape file feature class geometry of the objects within the class. The feature classes used to represents the objects as points, lines and polygons. The polygon feature class as below Figure 3.3.

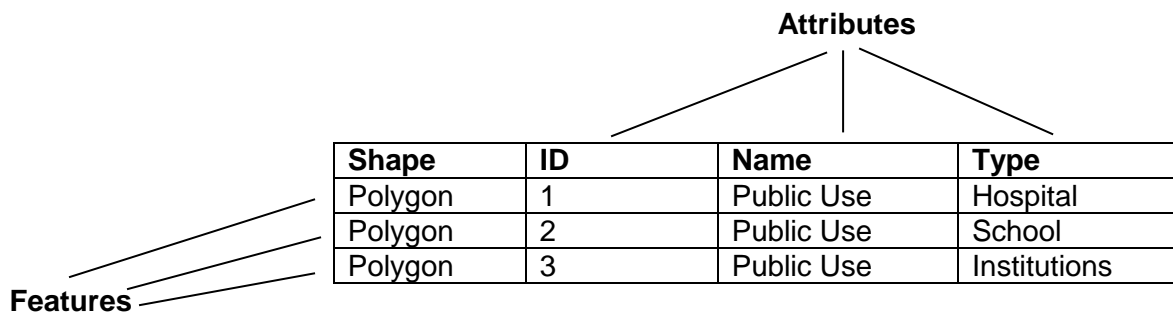


Figure 3.3: Polygon Feature Class

GIS database shows the detail information of urban planning in Nepal. This database is use for updating and future use in land use planning process. Present land use database prepared for this research is followed as Geo-database provided by NLUP specification and research knowledge as below Table 3.1.

Table 3.1: Database for Present Land Use Land Cover

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	FID
SHAPE	Geometry	Geometric Object type	SHAPE
ID	Long	Unique Object ID	ID
LEVEL1	String	Land Use Class	LEVEL1
AREA	Double	Area in Square KM	AREA

Data for the Rampur municipality has been organized into six feature datasets in which twenty feature classes are stored. The dataset also includes two raster datasets which includes satellite imagery for study area for 2015, Digital Elevation Model, Slope for the Rampur municipality. It includes demographics table from census 2011.

Table 3.2: List of All Datasets in Geodatabase

Feature Dataset	Feature Class	Feature Class Type	Description
Administrative Boundary	Municipality_Boundary	Polygon	Municipality Boundary
LULC	Land_Use_Land_Cover	Polygon	Land use land cover
Raster Datasets	DEM	Raster	Digital elevation model
	Geology	Raster	Geology Raster
	Elevation	Raster	Elevation Raster
	Slope	Raster	Slope model
	Aspect	Raster	Aspect Model
	LULC	Raster	LULC Raster
	Weighted_Final	Raster	Final Map
	Satellite_Image_PAN	Raster	Panchromatic Satellite Image

The ArcCatalog structure of geodatabase as below Figure 3.4.

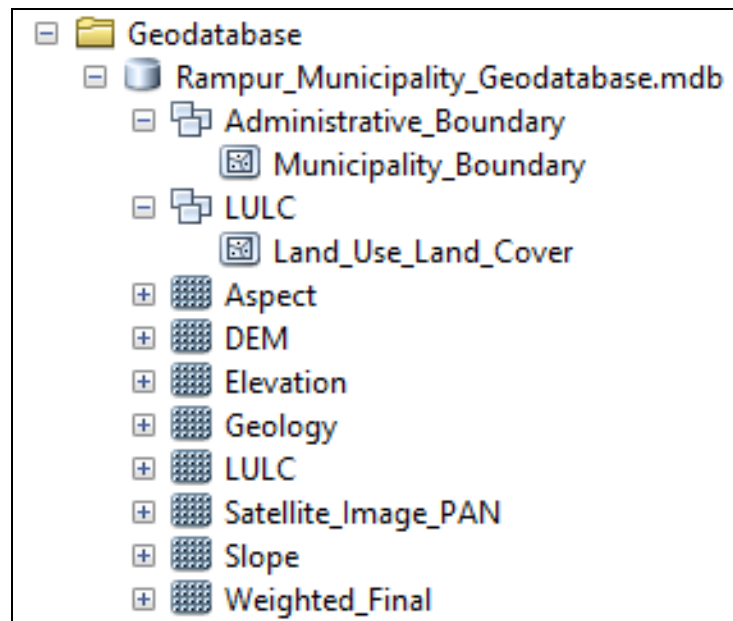


Figure 3.4: ArcCatalog Geodatabase

3.5 Land Use Land Cover

Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human activity (terracing, water storage or drainage structures, roads, buildings, etc.) (FAO, 1995).

Land use is a human activity such as agriculture, and building construction that alter land surface processes including biogeochemistry, and biodiversity. Social scientist and land managers define land use more broadly to include that the social and economic purposes and contexts for and within which lands are managed, such as subsistence versus commercial agriculture, rented versus owned, and private versus public land (Ellis, 2010).

Land use land cover (LULC) is the scalar dynamic. The change in land cover occurs even in the absence of human activities through natural processes whereas land use change is the manipulation of land cover by human being for multiple purposes food, fuel wood, timber, fodder, leaf, litter, medicine, raw materials and recreation. So many socio-economic and environmental factors are involved for the change in LULC. LULC change has been reviewed from different perspectives in order to identify the drivers of LULC change, their process and consequences (Khanal, 2002,).

LULC change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. LULC change have impacts on a wide range of environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and function, and the climate system itself through greenhouse gas fluxes and surface albedo effects (Lambin et al., 2000).

3.6 Classification System and Criteria

In almost any classification process, it is rare to find the clearly defined classes that one would like. In determining land cover, it would seem simple to draw the line between land and water until one considers such problems as seasonally wet areas, tidal flats, or marshes with various kinds of plant cover. Decisions that may seem arbitrary must be made at times, but if the descriptions of categories are complete and guidelines are explained, the inventory process can be repeated. The classification system must allow for the inclusion of all parts of the area under study and should also provide a unit of reference for each land use land cover type (Anderson et al., 1976).

There is no one ideal classification of land use and land cover, and it is unlikely that one could ever be developed. There are different perspectives in the classification process, and the process itself tends to be subjective, even when an objective numerical approach is used. There is no logical reason to expect that one detailed inventory should be adequate for more than a short time, since land use land cover patterns change in keeping with demands for natural resources. Each classification is made to suit the needs of the user, and few users will be satisfied with an inventory that does not meet most of their needs. In attempting to develop a classification system for use with remote sensing techniques that will provide a framework to satisfy the needs of the majority of users, certain guidelines of criteria must first be established. For this purpose taken the reference of the recently formulated land use policy as guidelines of classification and research knowledge.

A land use land cover classification system which can effectively employ orbital and high-resolution remote sensing image should meet the following criteria (Anderson et al., 1976):

- The minimum level of interpretation accuracy in the identification of land use land cover categories from remote sensing image should be at least 85 percent.
- The accuracy of interpretation for the several categories should be approximately equal.
- Repeatable or repetitive results should be obtainable from one interpreter or another and from one time of sensing or another.
- The classification system should be applicable to extensive areas.
- The classification system should be suitable for use with remote sensing image obtained at different times of the year.
- Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensing image should be possible.
- Aggregation of categories must be possible.
- Comparison with future land use data should be possible.
- Multiple uses of land should be recognized when possible.

For land use land cover data needed for planning purposes, the accuracy of interpretation at the generalized first levels is satisfactory when the interpreter makes the correct interpretation 85 to 90 percent of the time. The greater accuracy usually will be required for regulation of land use land cover activities.

3.7 Land Use Land Cover Class and Description

Land use land cover practice in any region of the country is governed by physiography, settlement pattern, cultural practices, climatic conditions and socio economic activities. The classification system has been recommended in TOR provided by the National Land Use Project (NLUP). The classification system with land use land cover categories as specified in the specification provided by NLUP and research knowledge should be

adopted. This will ensure the standardization among the classification result. National Land Use Policy 2012 provides the nomenclature of the Land Use Land Cover classes. The land use land cover level1 categories are Agricultural, Commercial, Forest, Industrial, Public Use, Residential, Road and Water Bodies as recommended in TOR and specification of land use policy 2012 and research knowledge.

3.7.1 Agricultural Land Use

Agricultural land is defined broadly as land used primarily for production of food and fiber. The areas those have been used for agricultural production such as cereals, cash crops, orchards, and so on. Use of land for different agricultural production differs due to physical (e.g. climatic condition, topography, soil) and social/cultural believes of the particular region. LRMP has broadly categorized cultivated land based on physiography of Nepal, namely Tarai, Hill, Mountain and Valley cultivation. The Mountain cultivation is further divided into Level terraces, Upland cultivation and Sloppy upland. Based on above information, the description of agricultural land use as below Table 3.3.

Table 3.3: Agricultural Land Use

Level1	Description
Agriculture	Hill Cultivation: Level terraces Upland cultivation Sloppy upland Cultivation

3.7.2 Residential Land Use

Residential areas are the built up areas used for housing purposes. Area of sparse residential land use such as farmstead will also be included in this category. This includes annex buildings like cow sheds, garage and farm house etc. This also includes features such as lawn area, well, private path, vegetable farm close to the house etc. The area delineated as residential area by government should also be categorized in this class.

Similarly, it is also divided in terms of origin of the settlement; old area, newly developed area (unplanned) and planned area such as colony type, parcels plotting area and housing complex etc. The description of residential land use as below Table 3.4.

Table 3.4: Residential Land Use

Level1	Description
Residential	Building, Housing complex Farm house, Parcel plotting House, Planned area

3.7.3 Commercial Land Use

Commercial areas are those used predominantly for the sale of goods and services. It consists of the main building, supporting structure and area that serve for commercial purpose. They are often abutted by, residential, agricultural, or other contrasting uses which help define them. It includes shopping centers, hotels, guest houses, shops, private schools, health centers, radio station, petrol pumps etc. Commercial areas are further description into service areas and business areas. The service areas include public services whereas Business area includes market area where exchange of goods and services occur. Commercial strip are situated along the highway and access route to the highway in this Municipality. The description of commercial land use as below Table 3.5.

Table 3.5: Commercial Land Use

Level1	Description
Commercial	Business Areas: Market and Bazar area

3.7.4 Industrial Land Use

Industrial areas are the areas where production of goods occurs. It includes a wide array of land uses from light manufacturing to heavy manufacturing plants. It includes area

covered by land, house and shed that are used as workshop or processing and manufacturing industry. It consists of factories such as textile, food, brick, timber, vehicle, brewery etc. It is further sub-divided into small scale industry including cottage industry, medium scale industry and large scale industry. The description of industrial land use as below Table 3.6.

Table 3.6: Industrial Land Use

Level1	Description
Industrial	Small Scale including Cottage Industry Medium Scale Industry Large Scale Industry

3.7.5 Forest Land Use

Area covered by vegetation completely or partially and which does not fall under above mentioned category is forest. It consists of area covered by forest, shrub and grazing land/grassland. It is an area with natural or planted trees along with shrubs and grass where the dominant species are trees of various kinds. On the basis of crown density, forest is classified as dense, sparse, degraded types. Similarly, according to the forest ownership category or use right, it is classified as private, protected, government managed, community, leasehold, collaborative and religious. The description of forest land use as below Table 3.7.

Table 3.7: Forest Land Use

Level1	Description
Forest	Tropical Forest Sub-tropical Forest Mixed Forest Shrub Forest

3.7.6 Public Use

Public uses are those services which cannot exclude someone to use it under certain terms of condition. Public land used by School, College, Hostel, Religious place, Parks, Stadium, Picnic spot, parking areas, and other public service activities are categorized in this class. The description of public use as below Table 3.8.

Table 3.8: Public Use

Level1	Description
Public Use	Educational: School, College Security Services: Police, Military Religious places: Temple, Mosque Health Service: Hospital, Health Post Recreational Facility: Park, Picnic Spot, Open Spaces, Playground, Parking: Bus Park Institution: Government, Public

3.7.7 Road

Road is the major transportation system of Nepal. The road network in Nepal is divided into a strategic road network (main highways and feeders roads) and a local road network (rural and urban roads). According to the Nepal Road Standard 2070, the classification of roads are classified into four categories. They are National Highways, Feeder Roads, District Road and Urban Roads. The road use like Highway, Feeder Road, District Road, and Urban Road categorized in this class. The description of road use as below Table 3.9.

Table 3.9: Road Use

Level1	Description
Road	Highway Feeder Road District Road Urban Road

3.7.8 Water Bodies

Nepal is the second richest country in terms of water resource availability in the world. The water resources one of the most important natural resources of the country. The water bodies uses are river, stream, pond, and canal categorized in this class. The description of water bodies use as below Table 3.10.

Table 3.10: Water Bodies

Level1	Description
Water Bodies	Water bodies: River, Stream, Pond, Canal

3.8 Present Land Use Land Cover Map

According to NLUP specification the existing land use land cover class includes seven classes they are Agricultural, Commercial, Forest, Industrial, Public Use, Residential, and Others. All other classes are standard classification besides public use class which includes three class i.e. public use, roads and water bodies in NLUP specification. In this research present LULC map was prepared using research knowledge and NLUP specification. The present LULC eight classes they are Agricultural, Commercial, Forest, Industrial, Public Use, Residential, Road, and Water Bodies.

Out of total area 123.34 Sq. Km. 54.50% area is covered by agriculture, commercial with 0.10%, forest area covers 38.92%, residential area covers 0.96%, public use area covers 0.39%, road area covers 1.40% and water bodies area covers 3.74% of the municipality. The present land use area is in sq. km. and their percentage as below Table 3.11. The pie chart and bar chart of present land use with their area presented Figure 3.5, and 3.6. The present LULC map of Rampur municipality Map 2.5 presented as pervious chapter.

Table 3.11: Present Land Use Land Cover Area and Percentage

Present Land Use Land Cover	Area in Sq. Km.	Percentage (%)
Agriculture	67.22	54.50
Commercial	0.12	0.10
Forest	48.00	38.92
Industrial	0.0008	0.0006
Public Use	0.48	0.39
Residential	1.18	0.96
Road	1.73	1.40
Water Bodies	4.61	3.74
Total	123.34	100.0

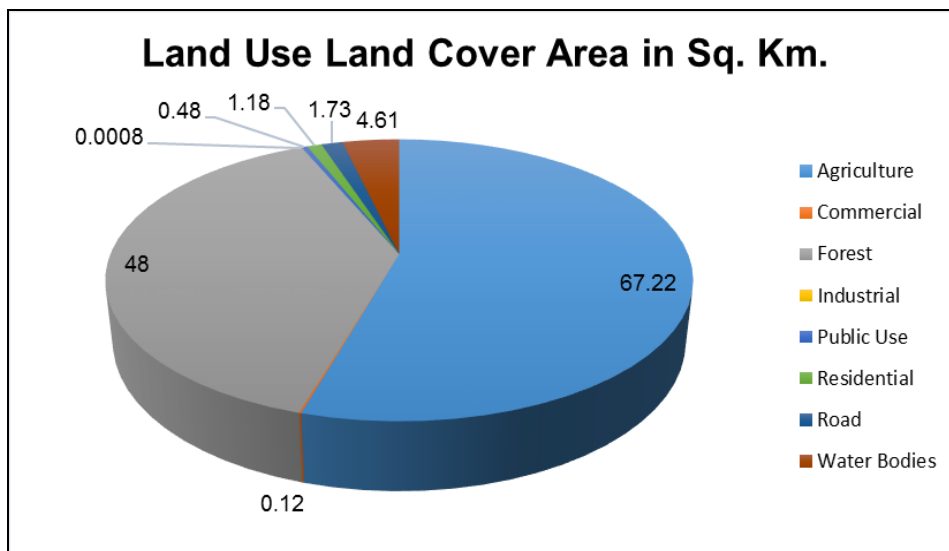


Figure 3.5: Present Land Use Land Cover Areas in Pie Chart

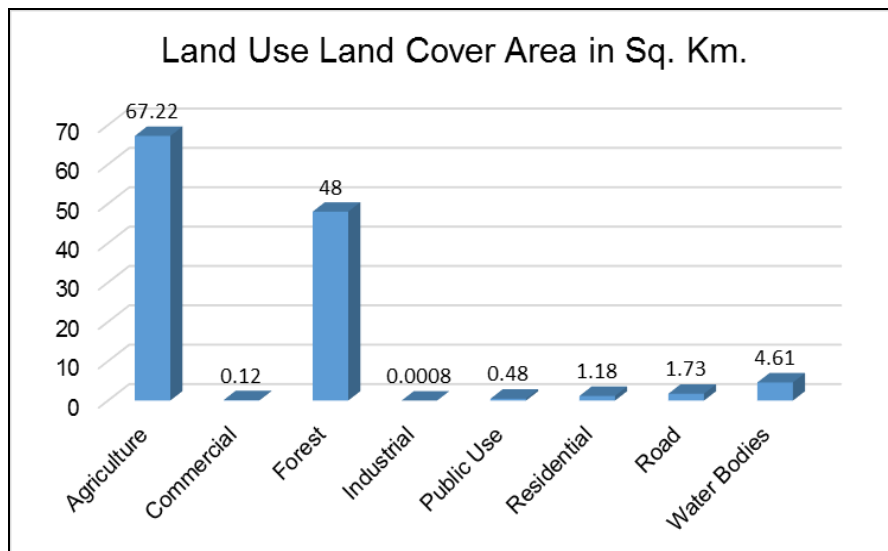


Figure 3.6: Present Land Use Land Cover Areas in Bar Chart

3.9 Suitability Analysis for Identifying Suitable Areas

The weighted was provided to the criteria on the value of 1 to 4 based on the research knowledge. 1 is being assigned to completely restrict for weighted overlay analysis. The suitability level and values of identifying suitable areas for urban development Suitability Level and Value Table 3.12 as below.

Table 3.12: Suitability Level and value

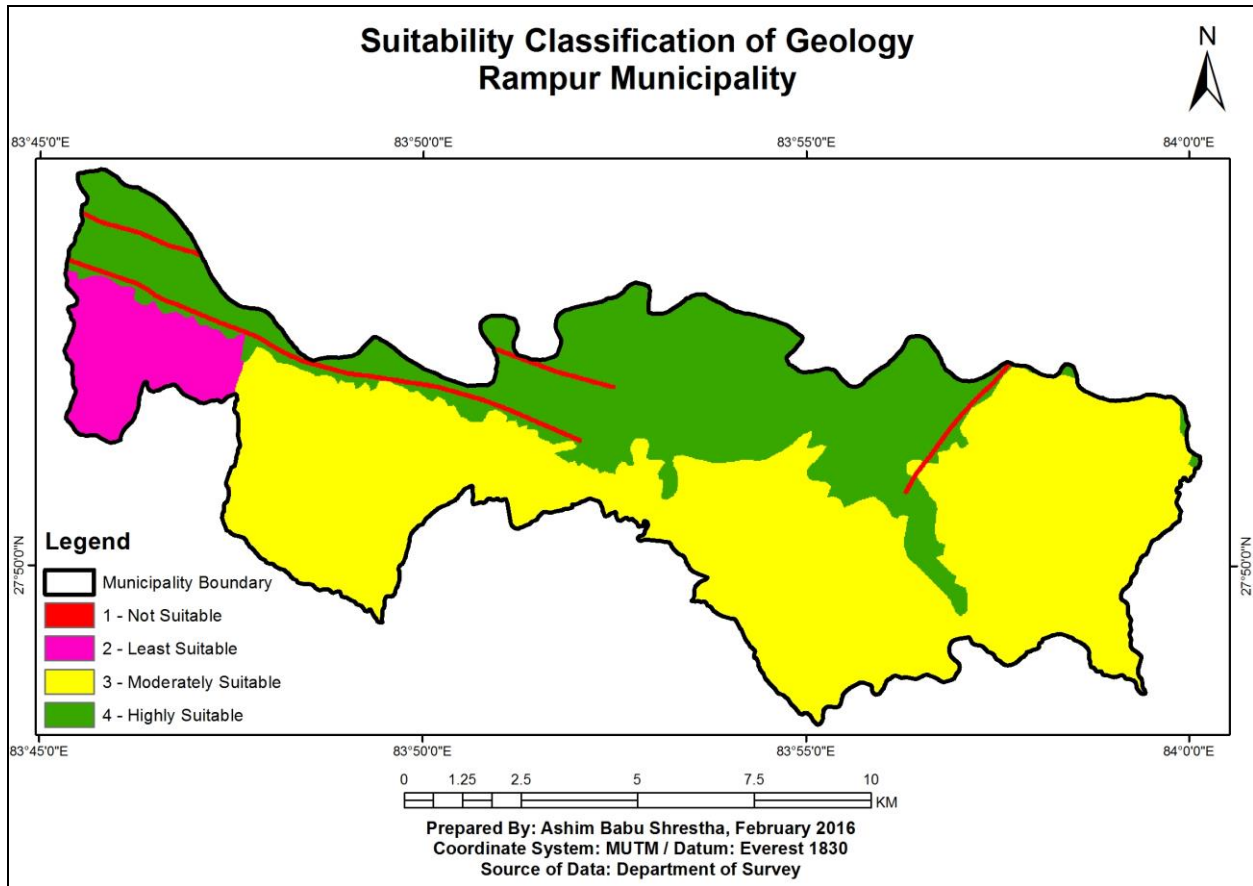
S. N.	Value	Suitability Level
1.	4	Highly Suitable
2.	3	Moderately Suitable
3.	2	Least Suitable
4.	1	Not Suitable

3.9.1 Geology

The geological categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Geology Weighted Value Table 3.13 and Suitability Classification of Geology Map 3.1 as below.

Table 3.13: Criteria for Geology Weighted Value

S. N.	Category Geology	Value	Suitability Level	Occupied Area in Sq. KM.
1.	Unconsolidated Sediments	4	Highly Suitable	38.77
2.	Sallyan Series	3	Moderately Suitable	74.21
3.	Midland Metasediments Group	2	Least Suitable	8.28
4.	Thrust Buffer 100m	1	Not Suitable	2.09



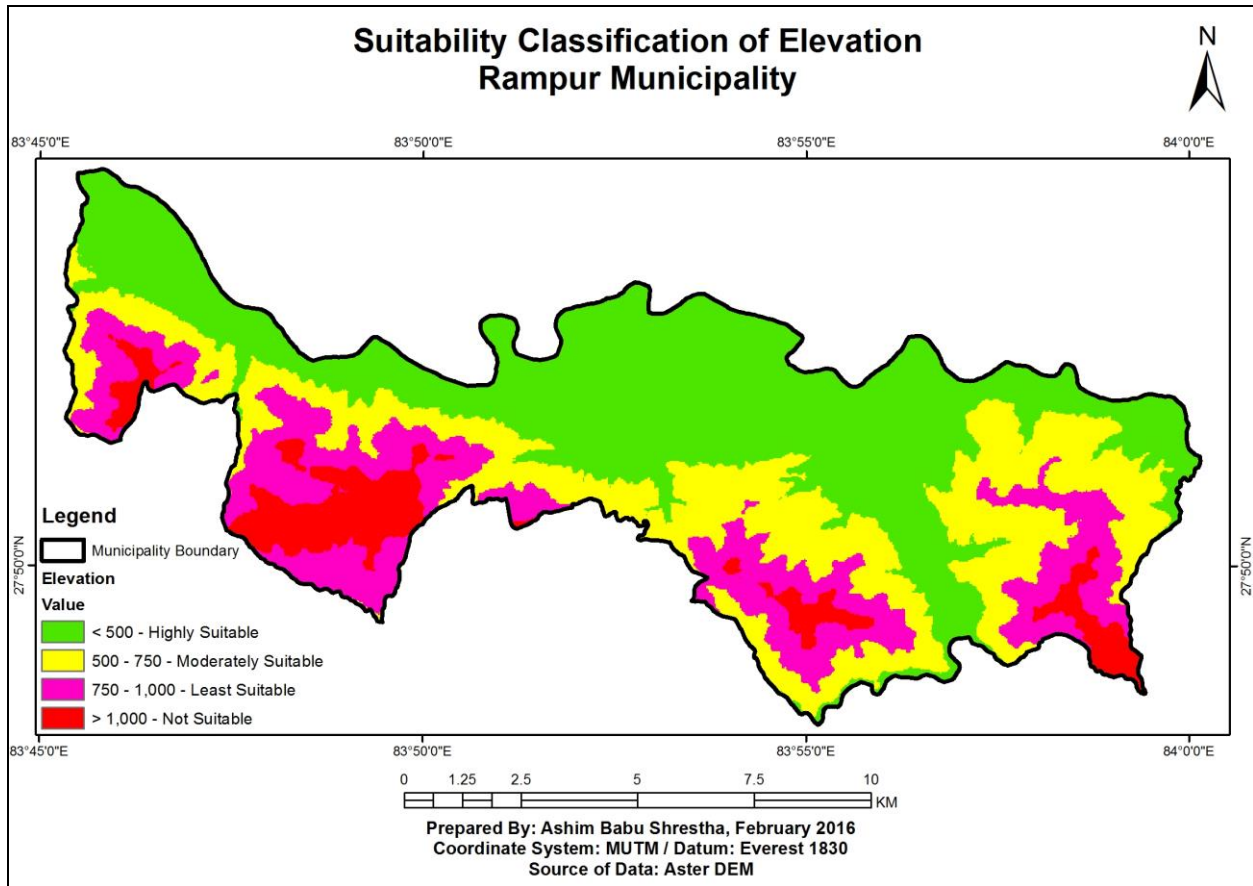
Map 3.1: Suitability Classification of Geology Map

3.9.2 Elevation

The elevation categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Elevation Weighted Value Table 3.14 and Suitability Classification of Elevation Map 3.2 as below.

Table 3.14: Criteria for Elevation Weighted Value

S. N.	Category Elevation	Value	Suitability Level	Occupied Area in Sq. KM.
1.	< 500m	4	Highly Suitable	53.25
2.	500 – 750m	3	Moderately Suitable	29.52
3.	750 – 1000m	2	Least Suitable	30.34
4.	> 1000m	1	Not Suitable	10.23



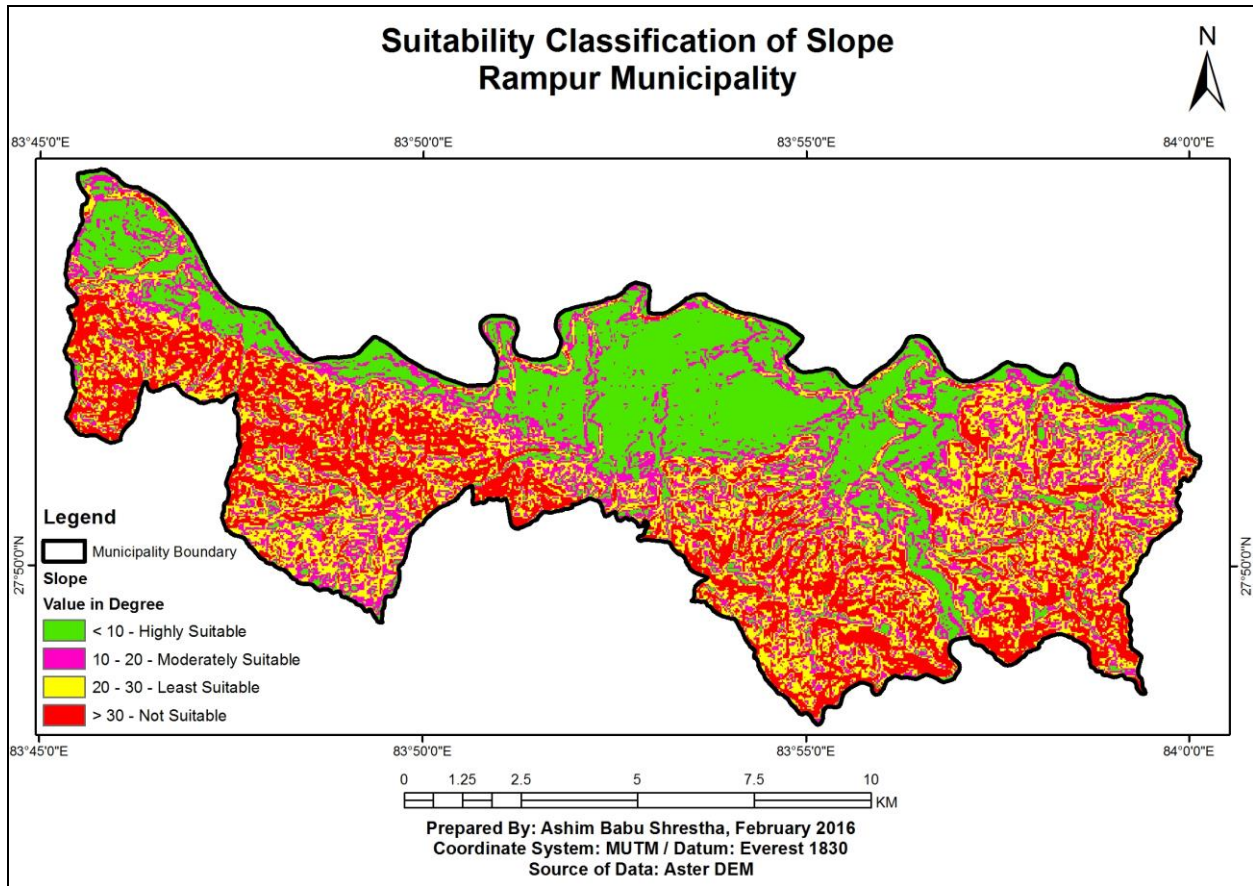
Map 3.2: Suitability Classification of Elevation Map

3.9.3 Slope

The slope categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Slope Weighted Value Table 3.15 and Suitability Classification of Slope Map 3.3 as below.

Table 3.15: Criteria for Slope Weighted Value

S. N.	Category Slope	Value	Suitability Level	Occupied Area in Sq. KM.
1.	0 – 10 Degree	4	Highly Suitable	35.90
2.	10 – 20 Degree	3	Moderately Suitable	17.58
3.	20 – 30 Degree	2	Least Suitable	28.13
4.	> 30 Degrees	1	Not Suitable	41.74



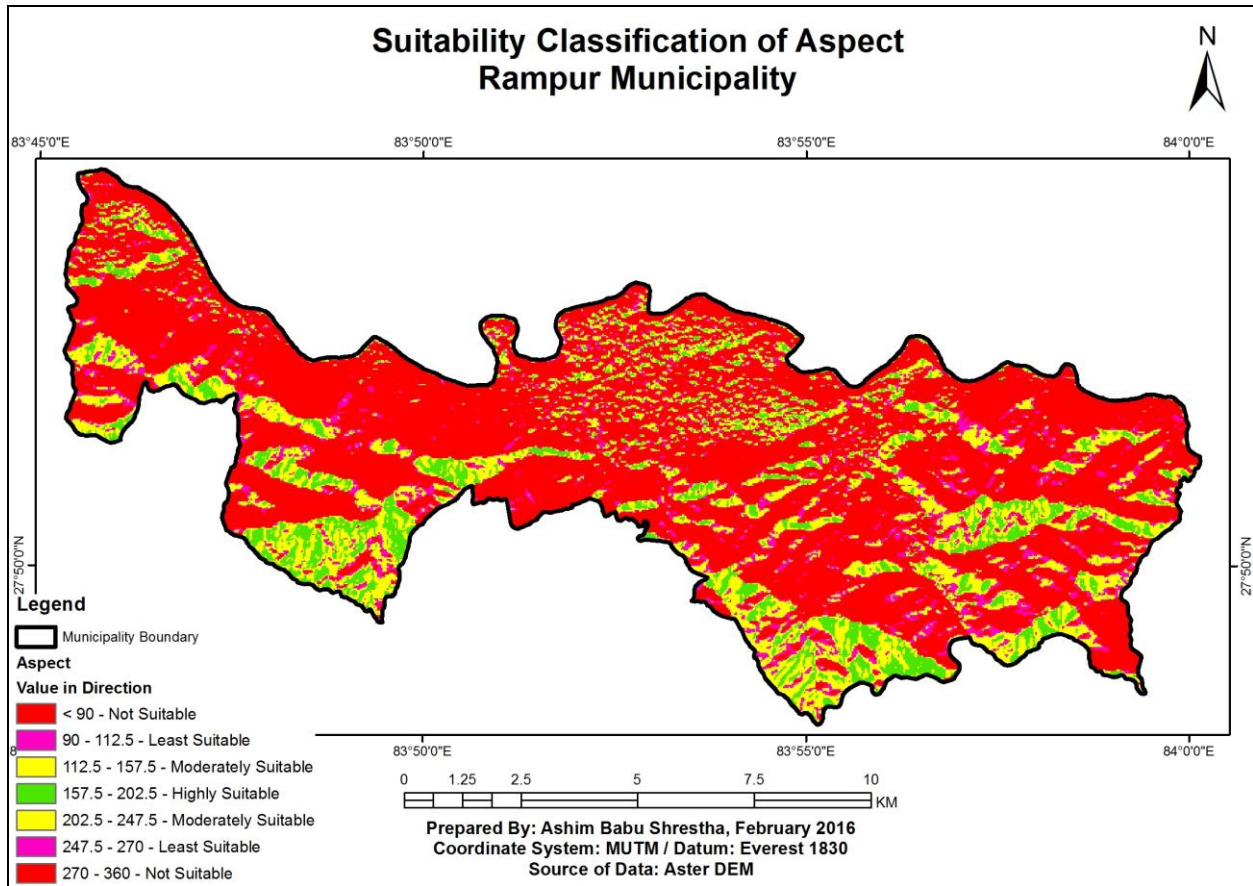
Map 3.3: Suitability Classification of Slope Map

3.9.4 Aspect

The aspect categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Aspect Weighted Value Table 3.16 and Suitability Classification of Aspect Map 3.4 as below.

Table 3.16: Criteria for Aspect Weighted Value

S. N.	Category Aspect Direction	Value	Suitability Level	Occupied Area in Sq. KM.
1.	157.5-202.5	4	Highly Suitable	11.57
2.	112.5-157.5 & 202.5-247.5	3	Moderately Suitable	14.83
3.	90-112.5 & 247.5-270	2	Least Suitable	10.51
4.	0-90 & 270-360	1	Not Suitable	86.43



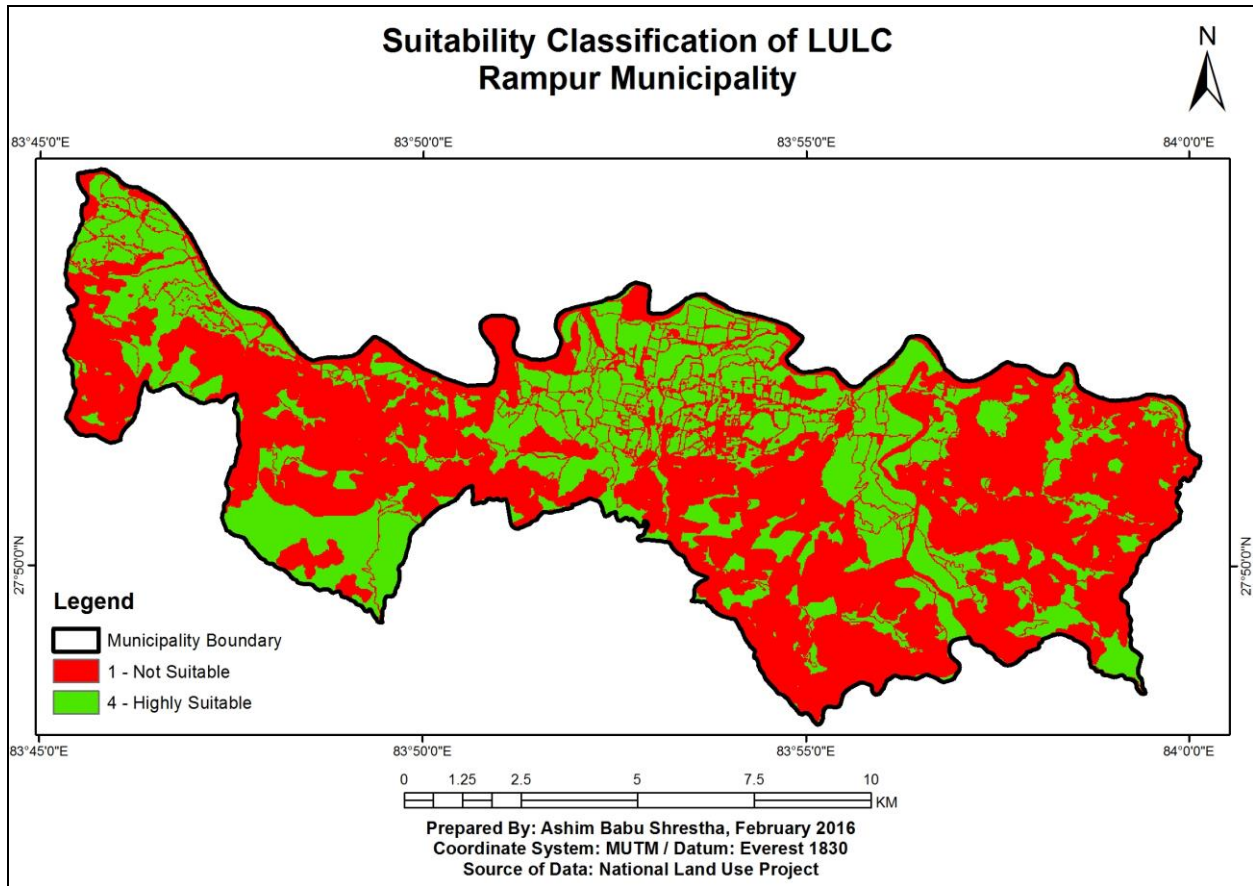
Map 3.4: Suitability Classification of Aspect Map

3.9.5 LULC

The LULC categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for LULC Weighted Value Table 3.17 and Suitability Classification of LULC Map 3.5 as below.

Table 3.17: Criteria for LULC Weighted Value

S. N.	Category LULC	Value	Suitability Level	Occupied Area in Sq. KM.
1.	Agriculture	4	Highly Suitable	45.99
2.	Buffer of Forest 100m, River 40m, Stream 20m, Commercial 20m, Industrial 20m and Road 20m	1	Not Suitable	77.35



Map 3.5: Suitability Classification of LULC Map

3.10 Suitable Areas for Urban Development

The suitable areas for urban development map was prepared on the basis of geology, elevation, slope, aspect and LULC with weighted value 1 to 4 i.e. not suitable to highly suitable where 1 is restricted value with weighted overlay analysis in ArcGIS software. The suitable areas for urban development map shown as below Map 3.6.

The Map 3.6 is the final resulting map which shows that 5.54 sq. km. areas within the Rampur municipality are highly suitable areas for urban development. There are many areas which are

not suitable and few areas are least suitable. The weighted overlay analysis and equal influence 20 in each raster as in Figure 3.7 as below.

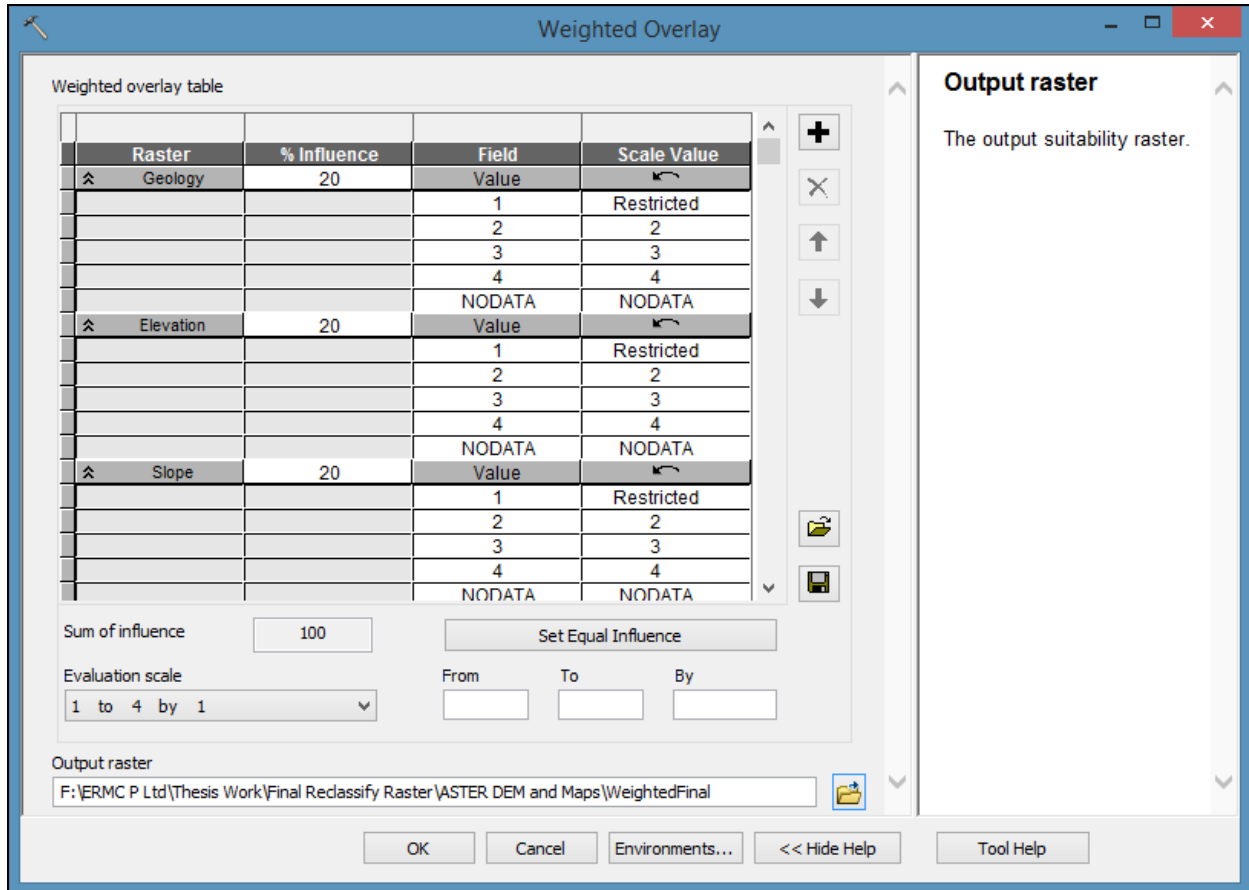
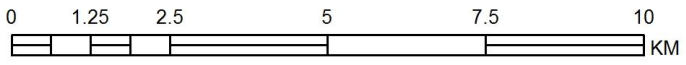
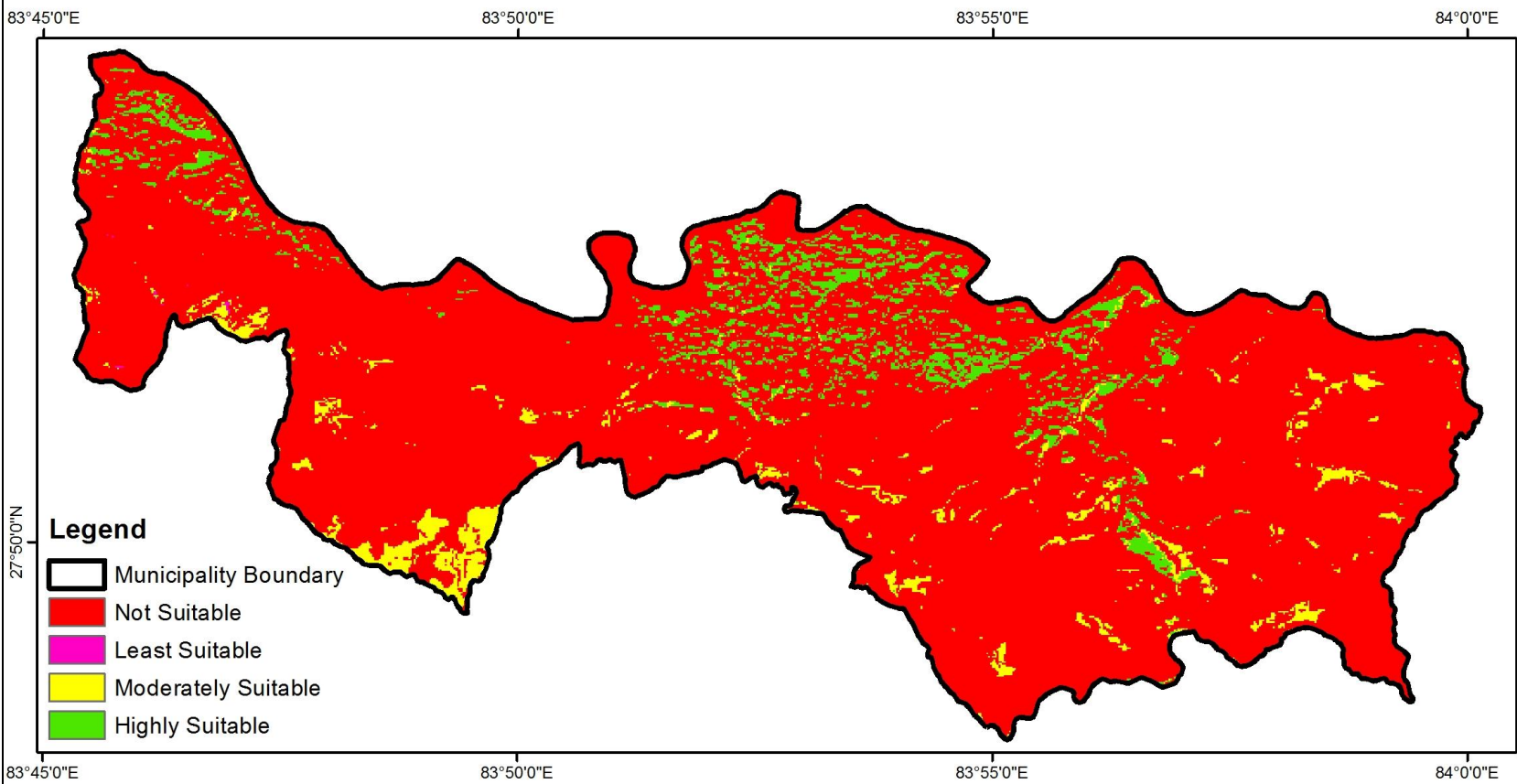


Figure 3.7: Weighted Overlay Analysis with Equal Influence

Suitable Areas for Urban Development Rampur Municipality



Prepared By: Ashim Babu Shrestha, February 2016
Coordinate System: MUTM / Datum: Everest 1830
Source of Data: Aster DEM / NLUP / DOS

Map 3.6: Suitable Areas for Urban Development

3.11 Result Analysis

The LULC result analysis:

The total areas cover by the agriculture i.e. 67.22 Sq. km. in Rampur municipality that is 54.50% of municipality area. Similarly the commercial areas of Rampur municipality is 0.12 Sq. Km. and it covers 0.10% of municipality. Forest area cover of 48.00 Sq. Km. and total percentage is 38.92%. There are no any industrial area except brick industry. So lack in industrial use among the others i.e. 0.0008 Sq. Km. area that is 0.0006%. Public use area cover 0.48 Sq. Km. with the percentage 0.39%. Similarly the total residential area is 1.18 Sq. Km. and its cover 0.96% of the area. The road area cover is 1.73 Sq. Km. and percentage is 1.40%. Water bodies area cover 4.61 Sq. Km. and percentage is 3.74% of Rampur municipality.

The suitable areas for urban development result analysis:

The summary of total area and percentage of suitable areas for urban development map of study area as below table. The result analysis of suitable areas for urban development as below Table 3.18, pie chart and bar chart Figure 3.7 and Figure 3.8 as below.

Table 3.18: Urban Development suitable Areas and Percentages

Level of Suitability	Range of Score	Colour	Area in Sq. Km.	Percentage (%)
Not Suitable	Class 1	Red	113.71	92.19
Least Suitable	Class 2	Pink	0.10	0.08
Moderately Suitable	Class 3	Yellow	3.99	3.24
Highly Suitable	Class 4	Green	5.54	4.49
Total			123.34	100.0

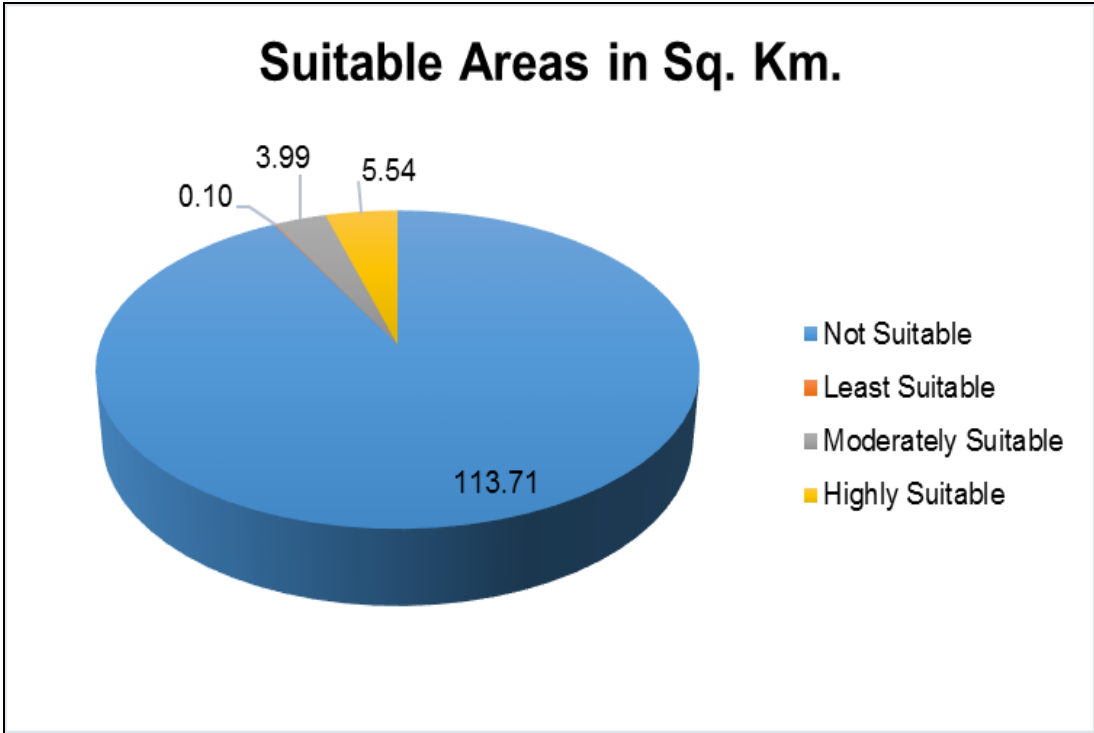


Figure 3.8: Urban development Suitable Areas in Pie Chart

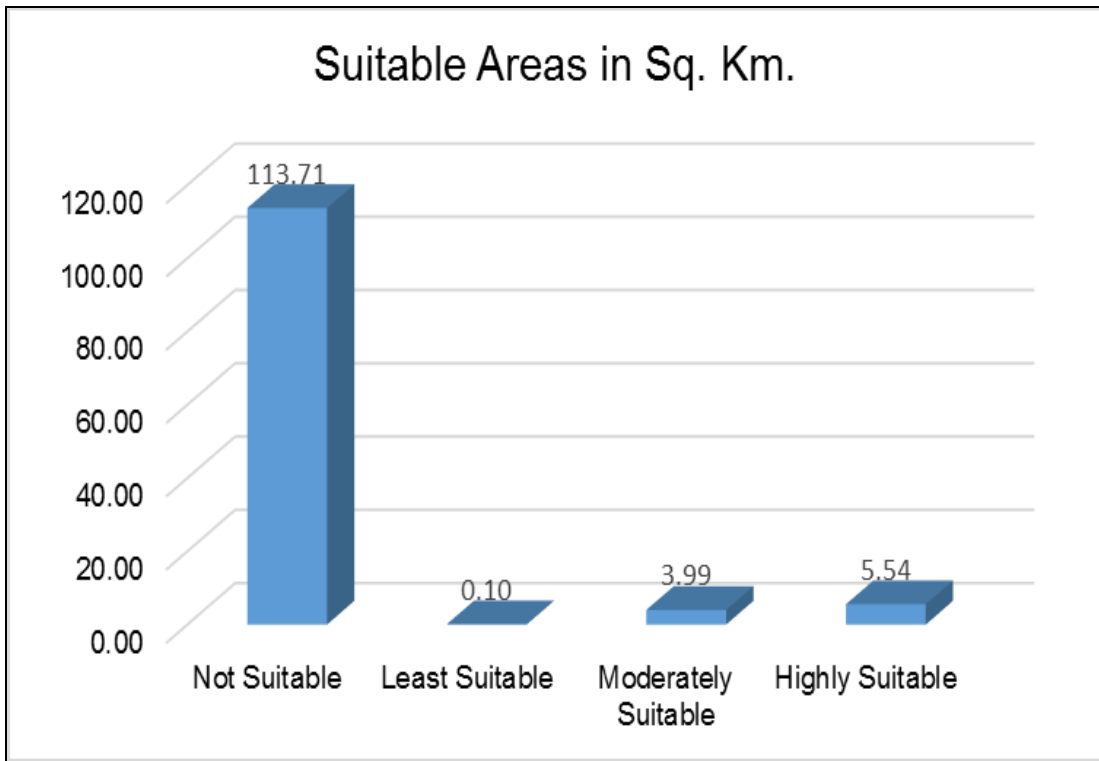


Figure 3.9: Urban development Suitable Areas in Bar Chart

According to the final result map 3.7 the highly suitable areas of 5.54 Sq. km. i.e. 4.49% cover. The list suitable areas of 0.10 sq. km. i.e. 0.08%, the moderately suitable areas 3.99 sq. km. i.e. 3.24% and not suitable areas 113.71 sq. km. i.e. 92.19%.

3.12 Conclusion

The purpose of this study is to familiarize the geodatabase concepts, types, models, and methods that are involved in this work. It presents the basic concepts of geodatabase, database types, concept modeling of database, database structure, and geodatabase support for LULC and urban development. Future used and easily database updating is the main purpose for database design for urban development of this research. This research discuss about the land use land cover, classification system and criteria, land use land cover class description, present land use land cover map and result analysis. Land use land cover classification system and criteria with land use categories as specified in the specification provided by NLUP and research knowledge should be adopted. The level1 categories of land use land cover such as Agricultural, Commercial, Forest, Industrial, Public Use, Residential, Road and Water Bodies are recommended in TOR, specification of land use policy 2012 and research knowledge. This research helps to identify the suitable areas for urban development of Rampur municipality.

Chapter- 4: Conclusions

4.1 Summary

Land use land cover and management is a distinctive cross-sectoral issue, as many stakeholders are involved. Therefore, single measures have very little impact in reducing demand for land. To reach a sustainable level of land use, a wide variety of instruments, including fiscal, economic, regulatory and planning tools, must be used in combination. Furthermore, the activities, strategies and instruments must involve the relevant stakeholders, such as representatives from the administration (national, state, district and local level land owners) and the different sectorial disciplines (regional versus urban planning, nature conservation and environment protection, economy and traffic) in order to efficiently achieve a sustainable level of land use. Even more important would be the involvement of the local bodies, the local people and the local user groups, which has been very much emphasized in the National Land Use Policy 2012.

The present research is fruitful as it produced geodatabase, land use land cover and identifying suitable areas for urban development maps on the theme, which will be fundamental technical reference for implementing land use plan at the municipality level. Such a database will certainly help the concerned authorities to think of the ongoing land use practices on the lands, the finite resources of the country. It will further help to develop plan for the local areas and implement accordingly. The land use land cover is important to ensure that land use considerations are fully integrated into analysis of development activities. In this sense, the urban development can be regarded as milestone for the planners and authorities working within the area for sustainable land development.

4.2 Conclusions

Urban growth and land use study is very useful in local government as well as in urban planners for the appropriate plans of land use planning in sustainable urban development. Urban development provides the knowledge for the planners and decision makers, the required information about the current state of development and the nature of changes that have occurred, physical conditions, public service accessibility, economic opportunities, local market, population growth, and government plans and policies are the driving forces of planning process. GIS and Remote Sensing provides spatial analysis tools which can be applied at the municipality, city and district level urban development planning.

GIS is an information system designed to work with data referenced by spatial references. GIS is an important aspect for urban planning, sustainable development, economic planning and uses of natural resources activities. GI Science is mapping and spatial analysis for both spatial and attribute data to support decision making process and activities. GIS provides decision makers, especially those concerned with the build environment, ways of creating enabling scenarios for making timely and information driven decisions to solve existing or identified spatial problems. GIS is considered as a design making tool in problem solving environment. Spatial analysis is a vital part of GIS and can be used for many applications like site suitability, natural resource monitoring, environmental disaster management and many more. The present land use pattern of the municipality under study is classified by using remotely sensed image with the help of ground based information.

Lack of clear guidelines on the classification system has posed a level of difficulty in assigning the classes of different hierarchy in land use categories. Hierarchical classification system helped in incorporation of complex land use pattern of this municipality. NLUP

specification and research knowledge classification system used in the study attribute to standardization in the land use land cover result among this municipality. Digitization and visual image interpretation incorporated with extensive field visit and use of ancillary data such as LRMP shape file, geology map, and topographical map. The land use classes yield better accuracy because the classes are designated manually based on ground knowledge and visual interpretation rather than automatic classification. These land use land cover data and suitable areas for urban development map can be used to formulate land use and other plans for the municipality under study. Further it can also be used for management activities and regulating LULC and urban development activities in the Rampur municipality.

The present land use land cover classified in eight categories of Rampur municipality and they are Agricultural, Commercial, Forest, Industrial, Public Use, Residential, Road, and Water Bodies. The total study area is 123.34 Sq. Km. The areas cover by the agriculture i.e. 67.22 Sq. km. that is 54.50%. The total commercial areas is 0.12 Sq. Km. and it covers 0.10%. Forest area cover of 48.00 Sq. Km. and total percentage is 38.92%. The industrial area like brick industry are in few number. So lack in industrial use among the others i.e. 0.0008 Sq. Km. area that is 0.0006%. Public use area cover 0.48 Sq. Km. with the percentage 0.39%. The total residential area is 1.18 Sq. Km. and its cover 0.96% of the area. The road area cover is 1.73 Sq. Km. and percentage is 1.40%. Water bodies area cover 4.61 Sq. Km. and percentage is 3.74% of Rampur municipality.

The total areas cover by the not suitable i.e. 113.71 Sq. km. in Rampur municipality that is 92.19% of municipality area. The least suitable area cover of 0.10 Sq. Km. and total percentage is 0.08%. The total moderately suitable area is 3.99 Sq. Km. and its cover 3.24% of the area. The total highly suitable areas of Rampur municipality is 5.54 Sq. Km. and it covers 4.49% for suitable areas for urban development.

4.3 Recommendations

This research is fruitful as it produced maps, geodatabase and suitable areas for urban development on the theme, which will be fundamental technical reference for implementing urban development at the municipality level. Such a database will certainly help the concerned authorities to think of the ongoing land use land cover practices on the lands, the finite resources of the country. It will further help to develop plan for the local areas and implement accordingly. In this sense, the land use land cover can be regarded as milestone for the planners and authorities working within the area for urban development. The achievement of sustainable and environmental development through the urban development and its sources firstly requires adoption of strategic urban development planning including;

1. Regulating and discouraging unauthorized land use.
2. Maintaining balance between development and environment.
3. Controlling the fragmentation of land and haphazard urbanization.
4. Determining allowed land use of specific land parcels, and ensure implemented and monitored.
5. Determining appropriate policy measures.
6. The geodatabase useful for future use and map updating.
7. This research thesis is useful for planner, land expert, engineers, surveyors and who involves the urban development process.
8. It takes the model research for urban development process in municipality level of Nepal in hilly area.
9. This research is more useful for urban and regional planning and researchers of colleges and university level students and teachers.

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Appendix I DGPS Coordinate List

DGPS Coordinate List

S. N.	Name	East	North	Ortho height	Reference
1	GCP1	486497.941	3082639.534	414.076	
2	GCP2	482754.481	3083460.481	386.029	
3	GCP3	476589.998	3086444.046	462.548	
4	GCP4	480591.643	3080285.735	1160.103	
5	GCP5	489733.073	3078546.502	841.393	
6	GCP6	499849.311	3082284.667	306.837	
7	GCP7	495214.94	3078653.482	445.242	
8	GCP8	490017.536	3083897.615	383.785	Base Point

Appendix II Specification of Satellite Image

The specification of Digital Globe Satellite Image

Specifications	Description
Spectral Bands:	Panchromatic (Black and White) & Multispectral (Red, Green, Blue and NIR), These image uses for visual image interpretation and land use mapping purpose.
Resolution:	1-m Panchromatic & 2-m Multispectral
Revisit Time:	1.7 days (depends on latitude)
Positional Accuracy:	6.5-m CE and 6.5 linear (does not account for topographic distortions)
Swath Width:	15.2-km at nadir
Date:	2015-03-07 05:12:23 GMT 2015-03-07 05:12:38 GMT
Dynamic Range	11 bit per pixel
Percent Cloud Cover:	0.4 0% over the study area
Orbital Altitude:	496-km Digital Globe
Sensor Arrangement	Linear Array

Projection	Hemisphere	Zone number	Datum
UTM	N	44	WGS84

Appendix III Panchromatic Satellite Image

Panchromatic Satellite Image of the Study Area

